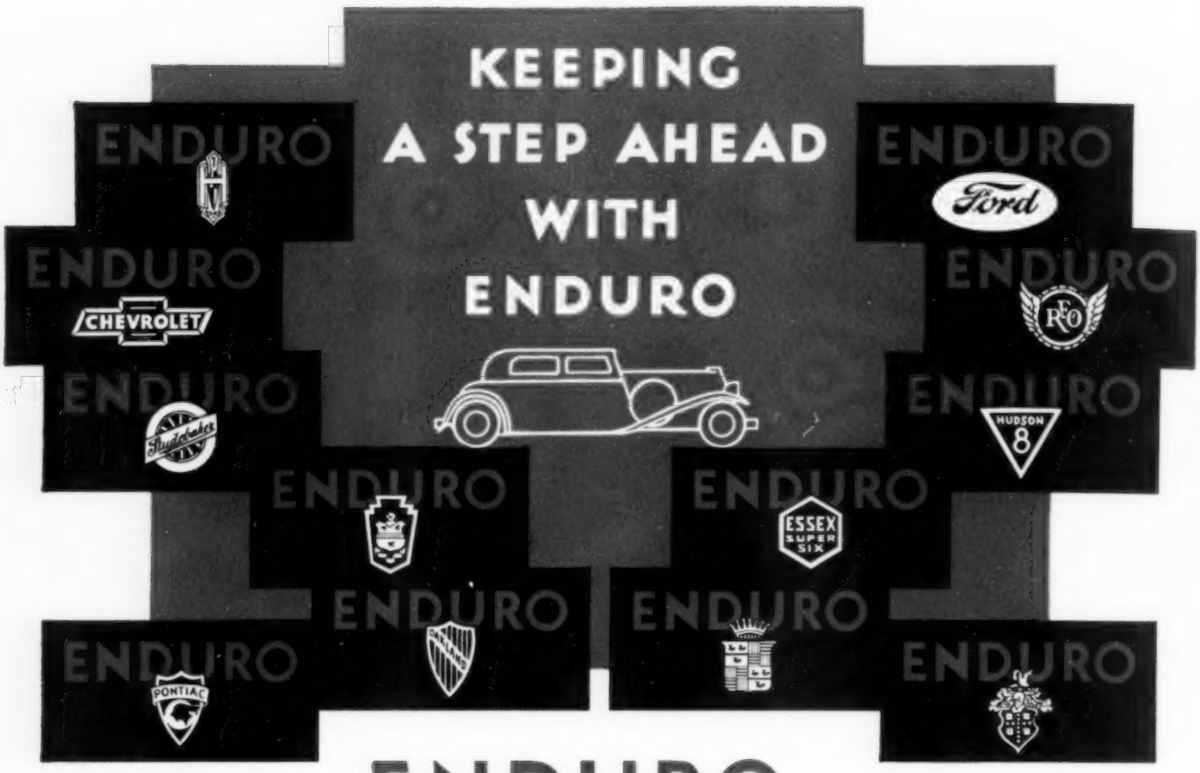
APR 1 1931

METAL PROGRESS

APRIL 1931



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Metal Progress

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Ernest E. Thum, Editor

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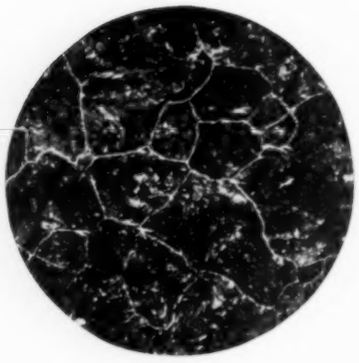
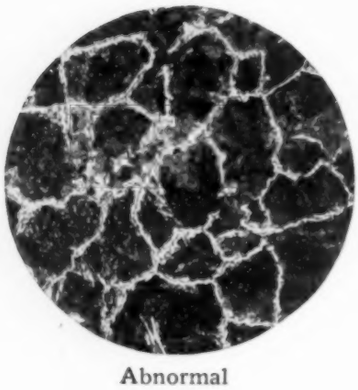
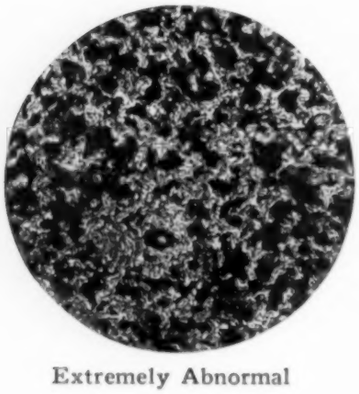


Normal



Abnormal



Extremely Abnormal

The Abnormality Test assures perfect hardening properties in Timken Alloy Steels

The abnormality test was devised and developed in the plant of The Timken Steel and Tube Company. Its purpose, as the name implies, is to distinguish normal from abnormal steels. Its object is to assure 100% hardening efficiency in all grades of Timken Alloy Steels intended for carburizing.

While it concerns the physical structure of the steel, the abnormality test must not be confused with the grain size test. Normality and abnormality have nothing whatever to do with grain size. Grain size affects such qualities as ductility and toughness of the steel, while normality and abnormality refer to its hardening properties.

Thus it is possible to have abnormal steel of correct grain size, or normal steel of incorrect grain size.

In normal alloy steel of any pre-determined grade, the structure of the carburized case consists of grains having sharply defined boundaries, forming a network, which the metallographist calls excess cementite. If the boundaries of the grains are not sharply defined, but are distorted and broken up, the steel is abnormal.

Normal steel hardens uniformly, whereas abnormal steel is subject to uncontrollable irregularities in hardening, such as soft spots.

The photo-micrographs reproduced above show typical examples of normal and abnormal steels of the same grade. Note the difference in structural formation.

Prior to the discovery of the abnormality test there was no reliable method of accurately pre-determining hardening characteristics in alloy steels.

THE TIMKEN STEEL AND TUBE COMPANY, CANTON, O.
Detroit Chicago New York Los Angeles Boston

TIMKEN
Electric Furnace and Open Hearth
ALLOY STEELS

Heat Treated Rail Ends Resist Batter

By M. D. BOWEN
Superintendent of Welding
Milwaukee Railroad

. . . SINCE 1926, the Chicago, Milwaukee, St. Paul & Pacific Railroad has used the oxy-acetylene welding process for building up battered rail ends. This is commonly practiced by many railroads, and is a means whereby maintenance gangs can replace metal which has been pushed aside near the rail ends by the impinging wheel loads. Low spots on the running surface, formed in this way in well ballasted and smooth track, are possibly caused by the fact that metal at the very end of the rail is not so well supported from all sides as it is some distance farther along, and consequently yields more readily. At any rate, the situation must be corrected promptly, else damage to track and rolling stock arises at a cumulative rate, to say nothing of the riding comfort lost by the passengers.

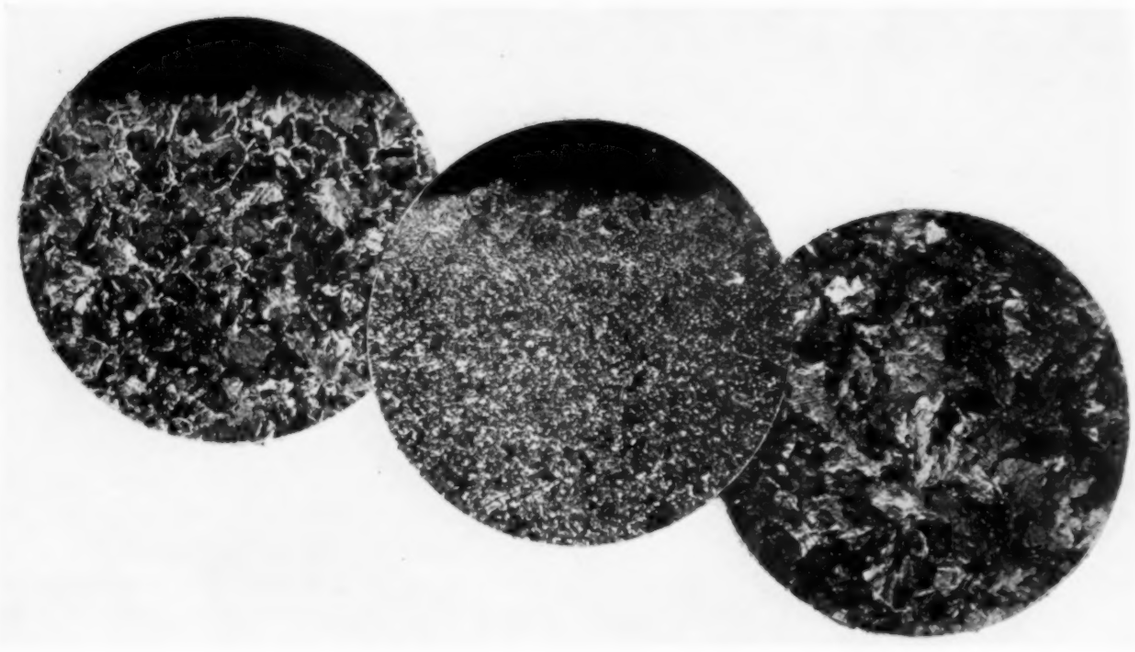
A standardized technique for such welding has been perfected, and it can be done efficiently and economically. The weld metal put down and peened to smooth surface is somewhat higher in carbon than the standard rail analysis (0.75%) and it is common knowledge that a new rail which may acquire batter in three years will maintain a smooth riding surface longer than three years after rebuilding, traffic and maintenance being equal.

Since it has been proven by experience that the ends of standard railroad rails are being overloaded by present main line traffic, and that these loads are successfully resisted by harder and stronger metal, laid on by welding, it occurred to the staff of the Maintenance of Way department of the Milwaukee road that the same effect could probably be achieved by a hardening and toughening treatment applied to the extreme end of new rails. At any rate, it was worth a trial, for it is obviously far better to prevent rail batter than to correct it. A brief summary of the development of this idea follows.

In July, 1927, 55 rail ends were treated by heating to about 1,450° F. and quenching with water. Some chipping and shelling out was noticed within two or three months but the joints that did not chip or shell out showed an excellent top surface, and all flow of the metal over the end of the rail had ceased.

A further test was made on five miles of new rail in the same territory. The procedure was the same except that a hot-cut chisel was driven between the ends while the abutting rails were red hot, to provide a bevel and prevent the top surface of the rail ends from meeting when the hot rail was in the expanded condition. Chipping under traffic was reduced, but not eliminated entirely, and after several months there were some rails found shelled out on the top surface in the treated areas.

However, the results were so encouraging that the test was then extended another six miles. These rails were beveled on a $\frac{1}{16}$-in. radius across the top surface of the end of the rail by filing with a coarse file. This was done before heat treatment, and before the rail was laid. The rail ends were then heated to about 1,450° F., quenched to atmospheric temperature, reheated to about 500° F., and left to cool in the air. This seemed to be somewhere near the correct procedure, for several months' service showed no chipping or shelling out. However, there was some variation in hardness, rail to rail, as could readily be observed in the condi-



Microstructure of Normal Rail Steel At Edge, Brinell 269, and At Edge After Heat Treatment, Brinell 356. Unaffected portion of treated rail is also shown. All at 100 diameters. Micros by L. E. Grant, Chief Chemist, C. M. St. P. & P. R.R.

tion of rails in service. It was decided to raise the quenching temperature to about 1,500° F., and the drawing temperature to 650° F., and this practice showed some improvement.

By this time we had treated nearly 50,000 rail joints, judging the quenching temperature by eye with considerable success. Experience indicated the need for greater accuracy in controlling the quenching temperature. Many pyrometers were tried, until a suitable one (later to be described) was found. The addition of this pyrometer makes it possible to secure positive control of each cycle of the operation. At present the pyrometer is not used on each joint, but is used by the foreman at frequent intervals as a check on the judgment of the men doing the heating.

It is apparent that the method to be used is quite similar to a number of different heat treating operations (spot hardening, spot annealing) frequently done by intense torch flames. *Oxy-Acetylene Tips*, for February 1926, describes many common ones performed with a welding torch, such as hardening the corners of carpenters' squares, the ends of gas engine valve stems, spots on malleable iron rifle-parts, and teeth in band saws. No revolutionary principles are involved.

It is necessary to proceed as follows:

1. Use a uniform flame. Cone of the flame (partially burned gases) must not come in contact with the material to be treated.

2. Heat required area to approximately 1,500° F., which is well above the critical.

3. Heat it slowly enough so the temperature gradient through the cooler metal surrounding the hot spot will not cause high differential expansion with incipient cracking.

4. Heat it rapidly enough to localize the heat, so only the required area at the rail end will be hardened.

5. Quench the hot spot rapidly.

6. Reheat the hardened spot gently to 650° F., which will draw the temper—that is to say, toughen it.

Even though the principles involved are obvious to metallurgists, it will be realized that the application must be under close control on account of the importance of the members being heat treated. A railroad rail is something that must have the utmost reliability. Nothing must be done which will introduce brittleness into this metal carrying heavy loads at high speed. It is unnecessary to remind metal men that the

whole steel industry adopted open-hearth melting, after the rail makers had turned to this process in order to supply the railway demand for tough, low-phosphorus rails. Consequently it would be a long step in the wrong direction if, in attempting to make the rail ends more resistant to wear, they were also made more liable to breakage.

This possibility has, we are sure, been successfully avoided, primarily by careful regulation of the heat treatment procedure, and especially by a close control of the hardening and drawing temperature.

Prior to heat treating, a V-notch ¼-in. wide by ⅛-in. deep, is ground at the abutting rail ends, as shown in the drawing on the next page, thus chamfering the corner where the running surface of the rail ball is cut off square. This is done to provide a false expansion gap to keep the top surfaces of the end of the rail from touching, and also to provide a buttress to support the metal at the top surface at the end of the rail.

This work is done with V-edged grinding wheels, driven by 10 ft. of flexible shaft from a small gas engine. Two of these sets are provided for the hardening gang. Each is mounted on a pair of double flanged wheels and can easily be trundled along, or derailed by two workmen. These two men take turns in grinding the joint, as photographed below.

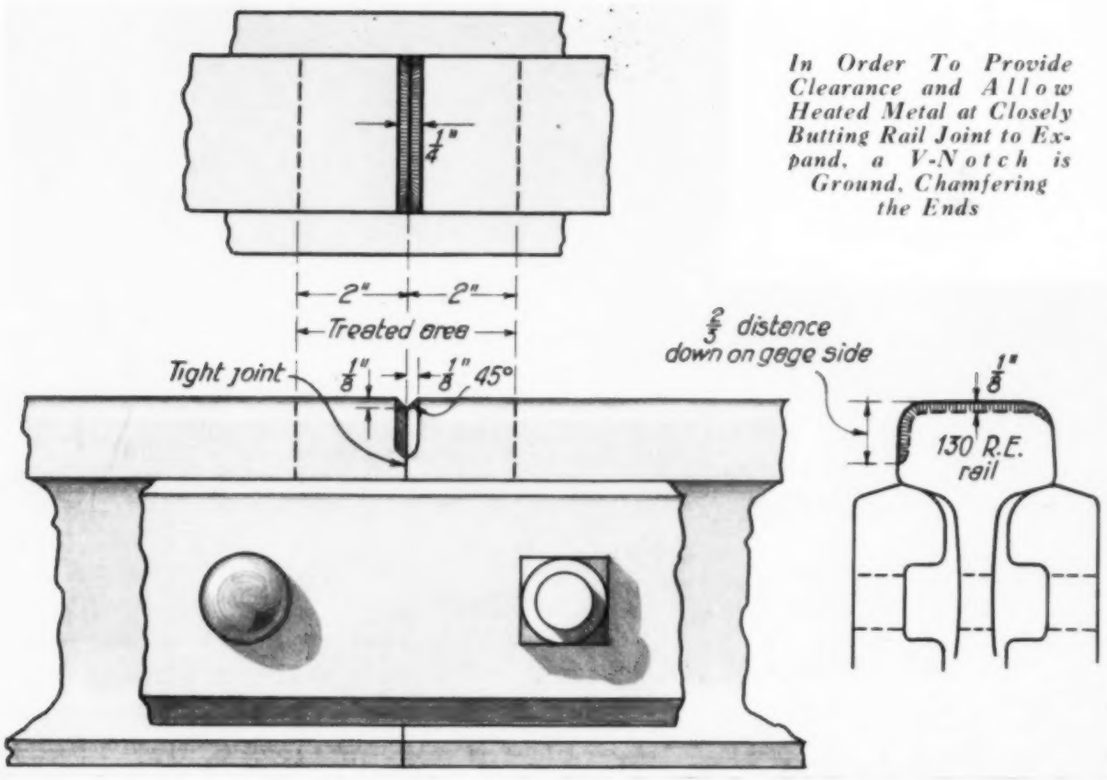
It might be thought that such a V-notch, producing as it does a narrow gap in the smooth running surfaces of the rail at 39-ft. intervals, would promote the very thing that heat treatment is expected to prevent, namely, a battering and slow flow of metal when the impinging wheel load strikes this sudden irregularity in the track. But experience shows this supposition to be erroneous. A similar V-notch cut across the ball of a rail mid-length (not heat treated) has been observed to be entirely ironed out by the wheel action within 1½ months in normal main line traffic. The hardened and tempered V-notch at the end of the same rail, however, is strong enough to resist this plastic flow, shown in photomicrographs, page 81.

The oxy-acetylene flame is ideal for the next or heating operation. Absolutely uniform in volume and intensity, it enables the heat to be applied in routine manner, one rail to the next. The equipment is well standardized and quite portable. We have assembled on several push cars, pulled by a large motor car, 20 cylinders of acetylene and 20 of oxygen with necessary hose and pressure regulators, and several barrels of water for quenching (of which about one quart is used for each joint).

Following the grinders are two men with special heating torches for this particular work. These torches consume about two to three times the amount of gases per hour that ordinary heavy-duty welding torches consume, and are equipped with a pilot flame so that the large tip is used only when the rail end is being heated.

Each torch man has one helper who stands

Small Gas Engine Drives Emery Wheel Through a Flexible Shaft. Two men constitute the gang, and take turns at grinding a notch at the rail ends



In Order To Provide Clearance and Allow Heated Metal at Closely Butting Rail Joint to Expand, a V-Notch is Ground, Chamfering the Ends

by with a supply of water ready to start the quench at the same instant the torch is removed from the rail.

Quenching temperature is controlled primarily by the uniform flame, and the heat at each spot is observed by the torch man just before quenching. Frequent checks are made by the foreman, to standardize the operator's eye, with the contact pyrometer shown on page 38. The principle of this instrument is as follows:

The thermocouple employed is made of rods of special alloys, (chromel and alumel). As shown by the views, the "hot ends" are pointed. Since the heated surface under test has a relatively low surface hardness, the points can penetrate very quickly, resulting in an almost instantaneous reading.

This "Alnor" pyrometer, so-called, operates on the thermo-electric principle. The alloy wires, when heated at one hot end, become at a different electric potential, and this causes a flow of electricity from point to point through the rail steel, up through the protruding rods and into a millivoltmeter. This meter is highly sensitive to small currents, yet rugged in construction. Its scale is graduated in degrees fahrenheit. The indicator is provided with an internal automatic cold end compensator, which takes care of changes in air temperatures.

The meter itself has an aluminum case 4½ in. diameter; the scale is 3½ in. long, reading to 2,000° F. In the range used in our operations each division marks 25° F. and it can easily be read to a half-division.

The over-all length of the instrument is 17 in. and the weight is about 3 lb.

We believe that the standardized procedure and the use of this pyrometer gives us quenching temperatures uniform to within 25° F. over the running and gage surface of the rail, a distance of 2 in. from the end.

Quenching is done by pouring water through several ⅛-in. holes in a row. These streams are moved back and forth over the hot spot and continue until steam bubbles cease forming, which means that the steel is approximately at 212° F.

Reheating is immediate. The torch flame is played over the abutting rail ends. Drawing temperature is controlled by observing the con-

dition of a solder streak. When the heat is approaching the desired temperature (650° F.) a stick of "half-and-half" solder wiped across the joint will leave a silvery track, and the exact temperature is judged by the colors of the oxide film which forms slightly later. (This is also checked by pyrometer.) When the solder streak turns brown within two or three seconds after application, the temperature is very close to 650° F. If a brown color does not appear, or appears later, more heating is necessary and another application of the solder.

This work, as may be inferred, is done on new rail and is organized to keep pace with a special gang engaged in track laying. An ordinary day's progress would be about 10,000 ft. of track, or about 500 joints. Since abutting ends are heated simultaneously, each spot includes two rail ends. The number of spots heated, therefore, corresponds to the number of rails laid, or the number of joints in the track.

For such progress the heat treatment gang consists of the following: 1 foreman; 2 men beveling rail ends with two helpers; 2 men heating to 1,500° F.; 2 men quenching. One man with an ordinary welding torch will reheat and temper all of the rails that two men with larger torches can harden during the work period. One man operates the motor car pulling all the equipment. One man looks after all equipment on cars. This organization has heated as many as 750 joints in 10 hr.

It occurred to us that it might be more convenient to do this heat treatment at some central location. Costs were kept on the hardening, before laying, of rails distributed along the track. The results were not encouraging. In the first place, each rail required four heats and two quenches, whereas in the track two abutting ends are treated simultaneously. In the second place, nearly all of our new rail is loaded as needed in the steel mill, shipped direct to the section being relaid, and strung along the right-of-way, and if we were to organize a central heat treating operation, much needless handling and trans-shipment would be involved. Relative costs are on this order: per rail, in the track 25c; out of track 55c.

Laboratory studies have shown that only a limited region is affected by the above described heat treatment. Change in structure extends about ¼-in. below the top surface and back a similar distance from the gage edge. Test bars made from 130-lb. R.E. rail (a section adopted by American Railway Engineering Association in 1920) and others from corresponding but non-heat treated locations, give the following average results:

	Not Heat Treated	Heat Treated
Elastic limit	70,900	106,500
Ultimate tensile strength	128,000	198,000
Elongation	13.5%	7.0%
Reduction of area	17.0%	23.6%
Brinell hardness	280	363

These test bars were, as stated above, cut from the head portion of 130-lb. R.E. rail and the treated bar was treated afterwards in identically the same manner as the treatment of rail ends is carried out. However, the small section of the test bar responds to the heat treatment much more readily than the head section of an ordinary rail would, which shows up very plainly in the elastic limit, and also the Brinell

An Oversize Oxy-Acetylene Flame is Guided Back and Forth Over Tread of Rail at Joint, Heating Ends to 1,500° F. When this surface temperature is reached, the metal is immediately quenched by a number of 1/8-in. streams of water, directed by a special nozzle

Heat Treater's Eye is Calibrated Frequently By Taking the Temperature of Metal Said to be at Correct Quenching Heat. Close-up of contact pyrometer shows pointed alloy rods which, when pressed into hot metal, generate a contact electromotive force proportional to the temperature, and the resulting current is measured by a millivoltmeter built into the handle

hardness. We obtain a hardness on the treated rail ends of about 325, and this runs very uniformly. The average hardness of 130-lb. R.E. rail as rolled is about 280 Brinell. These results, it should be emphasized, represent 130-lb. R.E. sections bought under American Railway Association standard specifications. Chemical analysis falls within the following limits:

Carbon	0.72 to 0.89
Manganese	0.50 to 0.90
Silicon	Over 0.15

We have not purchased any medium manganese rails (manganese between 1.0 and 2.0%) and consequently have no experience with their track performance, or the propriety of local heat treatment of this alloy.

At rather rare intervals, the heat treatment discloses a small internal rupture. This is easily seen by the torch operator, since a flake or shell of metal, parting from the body beneath, heats to a visible color much sooner than the sound steel alongside. When this occurs the abutting rail end is heat treated according to standard practice, the defective rail end conspicuously marked and accurately located in the records. As soon as possible thereafter, one of the crews especially organized for building up old battered rail ends visits the location, removes the defective sliver of metal and replaces it with new steel, welded on, using the every-day procedure. Rails now being made are of such high quality, and mill inspection is so thorough, that we have never encountered a rail which could not be safely retained in track after repairing.

While the practice of heat treating rail ends is relatively new, in the three years since it was started by the Milwaukee road a total of 65,000 rails has been heat treated in this way. We are convinced that the desired result is being attained, namely, to retard the end batter. It is necessary to use a feeler gage to discover any depression in the oldest heat treated joints. The lowest ones, on tangent track, which now measure 0.004 to 0.008-in. below a long straight edge laid across the joint, were not heat treated until they had been carrying trains for several months, and we are inclined to believe that the bulk of this depression was caused by the traffic before the heat treating crew arrived. At any rate, the treated rails are still in most excellent condition after a length of service which, if they had been laid as received from the mills, would undoubtedly have required some rebuilding of battered ends.

Saving Tonnage in Cruisers

By LEWIS H. FAWCETT
Metallurgist, U. S. Naval Gun Factory

. . . NAVIES of the world in all times have exerted a great and beneficial influence on the advancement and improvement of metallurgical products by demanding, year after year, higher and higher standards in their specifications for metals and alloys. For examples: In the past, the struggle of armor versus projectile has been a most fruitful source of inspiration for the development of alloy steels. The origin of nickel, chrome-nickel, and other alloy steels and their early application to naval use is also well known.

Thus a constant desire for naval perfection has inspired steel manufacturers and metallurgists to originate these alloy steels which, slightly modified, are now used so extensively for automobiles and other devices possessed even by those in moderate circumstances.

Since the War, naval designers have placed even greater emphasis on quality rather than quantity. The so-called treaty cruisers were built to meet the limitations imposed by the Washington Treaty, which set a limit of 10,000 tons displacement for light cruisers and also specified that guns should not exceed eight inches in caliber; therefore, a more careful study of all materials entering into the construction of a ship was necessary, especially in regard to metals.

In designing vessels under these conditions the weight of all essential members must be reduced to a minimum without sacrificing strength. Detail fittings also must be given the utmost consideration with the view of saving weight by design, or by specifying the lightest metal or alloy suitable for the purpose. Reduction of scantlings to a minimum consistent with necessary strength, local welding, and the use of light metal alloys where only local strength is involved, are the novel features of these ships. Aluminum paint also is a factor in weight saving. All the weight so saved can be utilized to increase the number of guns, the speed, fuel capacity, or any other of the military features of the ship.

Weight saving in the principal structure of these vessels has been accomplished by reducing the scantlings to a minimum consistent with necessary strength, as noted above, by reducing the thickness of armor protection and its extent and by requiring the armor used to do double duty by designing the hull so that the armor is an integral part of certain strength members, instead of merely being bolted on as an outer layer. Lightening holes have been cut in deck beams and other structural parts as well, to reduce their weight.

But, as pointed out in an excellent paper given last November by the chief constructor, Rear Admiral George H. Rock, before the society of Naval Architects and Marine Engineers ("The 10,000-Ton Treaty Cruisers, With Particular Reference to the Salt Lake City and Pensacola"), there is a limit to the saving of weight by the reduction of strength members in a structure composed primarily of medium or low carbon steel such as these ships. Consequently further weight was saved in parts requiring only local strength, and in the detail fittings throughout the ship.

While these ships are not welded in their

Metal Furniture Made of Cold Rolled Aluminum Alloy Sheet Saves 60 Tons on 100 Tons of Steel Furniture Formerly Used. A single berth with drawers and lockers is shown

general structure, more welding has been done on them than on previous United States naval vessels. Welding of steel parts was confined to the attachment of fittings or to places involving only local strength.

Welding Saved Weight At Details

For instance, bulkhead plates were stiffened with steel bars welded on as ribs, instead of being stiffened by riveting on an angle, tee-bar, or other rolled shape. Brackets, knee-braces, and other such stiffeners were made of welded parts, as well as the plating of many bulkheads. Water and oil piping was practically all welded at the butts instead of being joined by the usual screwed or bolted fittings. Platform decks, deck-houses, and the superstructure generally had much welding during construction. Hatches and hatch frames were assembled by welding and the fittings for doors and hatches were attached by this method. Weight was saved by the use of welding wherever experience at the time of the design of these vessels warranted the use of this method of joining.

Possibly the most novel and interesting feature in regard to the materials specified in the design of this class of ship was the liberal use, where only local strength was involved, of light metal alloys — wrought and cast aluminum alloys being used for this purpose. This subject was discussed at length by Paul V. Faragher before the Society of Naval Architects and Marine Engineers last November. It is also more briefly considered in Volume II, "The Aluminum Industry" (McGraw-Hill) in a chapter entitled "Marine Construction and Equipment," written by I. O. Chesley and R. V. Davies.

Aluminum alloy sheets have been used for all partitions such as living spaces, office partitions, and stateroom bulkheads. Rolled aluminum products have also been fabricated into furniture for these ships. While wooden furniture is light and handy and is used to some extent, steel furniture has for years been used

on naval vessels because it is fire-proof and vermin proof. But steel articles are heavy and unhandy, and for this reason aluminum furniture, made of plates and shapes of approximately the same cross-sectional area but only about one-third the weight of steel, is now being used so extensively throughout the treaty cruisers that the crew's mess tables and benches are the only furniture still made of wood.

To enumerate a few of these applications, mention is made of aluminum furniture, such as built-in bunks, officers' mess tables, desks, chiffoniers, crew lockers, aluminum chairs for officers' cabins, staterooms, mess rooms, and offices. Mention may also be made of the use of cast aluminum alloys for numerous fittings, airport frames, lens frames, and blast covers on the ports on and above the second deck; ladder treads, bed plates for motors, and auxiliaries not subject to shock.

The Navy has experimented for years with the use of aluminum alloys on ship board, and at first considerable difficulty was encountered due to corrosion of these alloys from the action of salt spray at sea, accelerated by contact with other metals. However, the above difficulties were practically eliminated, before the construction of the 10,000-ton cruisers, by preventing contact of the aluminum alloys with other metals (or by adequate insulation where such contact was necessary), and secondly by protecting the aluminum from corroding media with paint or otherwise.

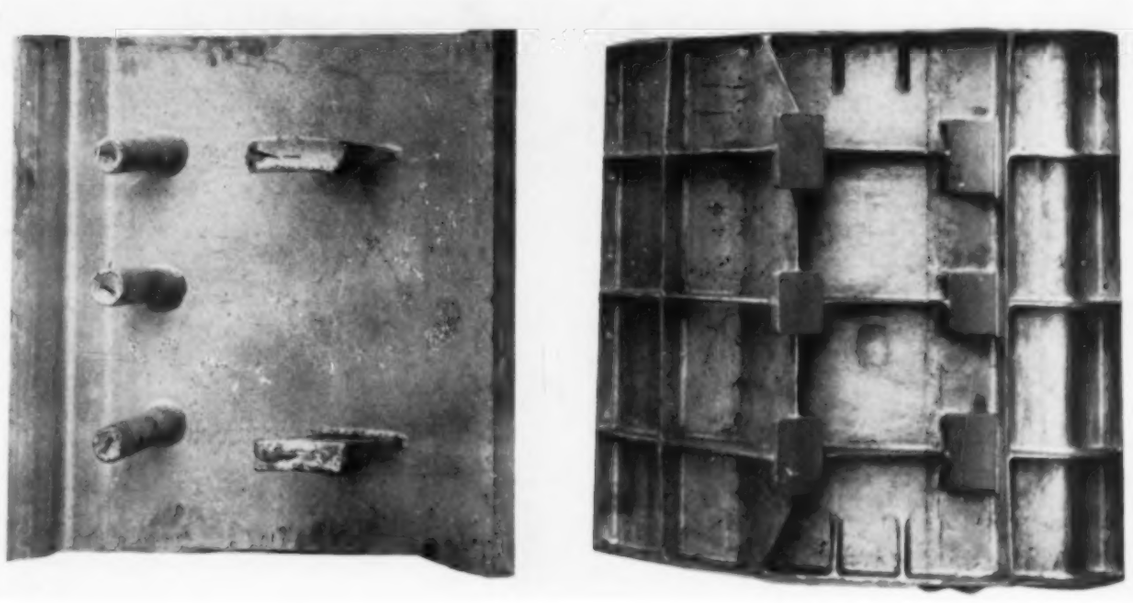
Methods of Avoiding Corrosion

Great care was exercised in the construction of these ships, where assemblies of aluminum were involved, to avoid direct contact with other materials, especially metals such as brass, bronze, copper, or steel. Where such contact was unavoidable, the faying surfaces were thoroughly insulated. Corrosion caused by the contact between aluminum and brass or copper is much more severe than that produced by aluminum and steel. Various methods were used to prevent this galvanic action between faying surfaces.

In one assembly where aluminum alloy sheets were secured to an aluminum alloy casting by means of steel bolts, the bolts were first dipped into asphaltum paint and after the bolts were made secure, their heads and the nuts were given another coat. Finally the completed assembly was painted with aluminum paint, thus presenting a very creditable appearance.

To protect moving parts, such as a steel pin moving in a lug attached to an aluminum cast-

● *Light Metal Castings and Duralumin Sheet Are Used for Ammunition Chutes. Precision castings with ribs $\frac{3}{16}$ in. thick require accurate cores and special molding practice*



REQUIREMENTS OF PRINCIPAL WROUGHT ALUMINUM ALLOYS

Composition	Condition	Tensile Strength	Yield Point	Elongation in 2 In.	Bend
	Aluminum-Manganese Sheet, Specification 47-A-4a				
Copper 0.2% max. Manganese 1.0 to 1.5 Aluminum 97.0 min.	Soft temper	14,500 min.		20 to 28%	
	Half hard	19,500 min.		3 to 8	
	¾ hard	24,000 min.		1 to 4	
	Hard temper	27,000 to 33,000		1 to 4	
	Heat Treated Aluminum Alloy, Rolled Products				
Copper 3.5 to 4.5% Manganese 0.4 to 1.0 Magnesium 0.2 to 0.75 Aluminum 92.0 min.	47-A-3, Sheet	50,000 to 55,000	25,000 to 30,000	12 to 18%	180°
	46-A-4, Rods and shapes	45,000 to 55,000	20,000 to 25,000	12 to 18	180°
	44-A-2, Tubes	55,000 min.	30,000 min.	14 to 18	–

ing, a steel bushing may be dipped in asphaltum or bituminous paint and permanently inserted in the casting so that the moving contact parts will both be steel. Washers are also of use in this connection.

When varnish or paint is used it is allowed to dry, and again painted just prior to assembling. Canvas used in contact with metal is treated to prevent the absorption of moisture and then soaked in these paints or in marine glue. Wood also absorbs moisture and when in contact with metal this moisture accelerates corrosion; it may be corrected by the use of marine glue between the contacting surfaces.

Material used in the manufacture of articles, such as furniture, was in accordance with Navy Department specifications 47-A-4a, aluminum alloy (aluminum-manganese) sheet. Requirements are noted in the table above.

Where higher mechanical properties were required a heat treated alloy was specified in accordance with Navy Department specification for aluminum alloy (aluminum-copper-magnesium-manganese). Three specifications covering this one composition with varying mechanical requirements are known as 47-A-3, 46-A-4, and 44-A-2, and the composition and properties are given in the table.

The mechanical properties listed are for heat treated magnesium bearing material.

When this particular composition is desired in the annealed state, a maximum tensile strength of 35,000 lb. per sq. in. is specified, with a minimum elongation ranging from 8 to 16% depending on the form or shape of the material.

Navy Department specification 46-A-1a, aluminum alloy castings, governs the use of many parts. Class 2 alloy of this above specification is used for parts where strength is not important, due to its good casting characteristics and relatively good resistance to corroding influences. Class 4, an alloy requiring heat treatment, is used when greater strength is necessary. Chemical requirements of these two grades are

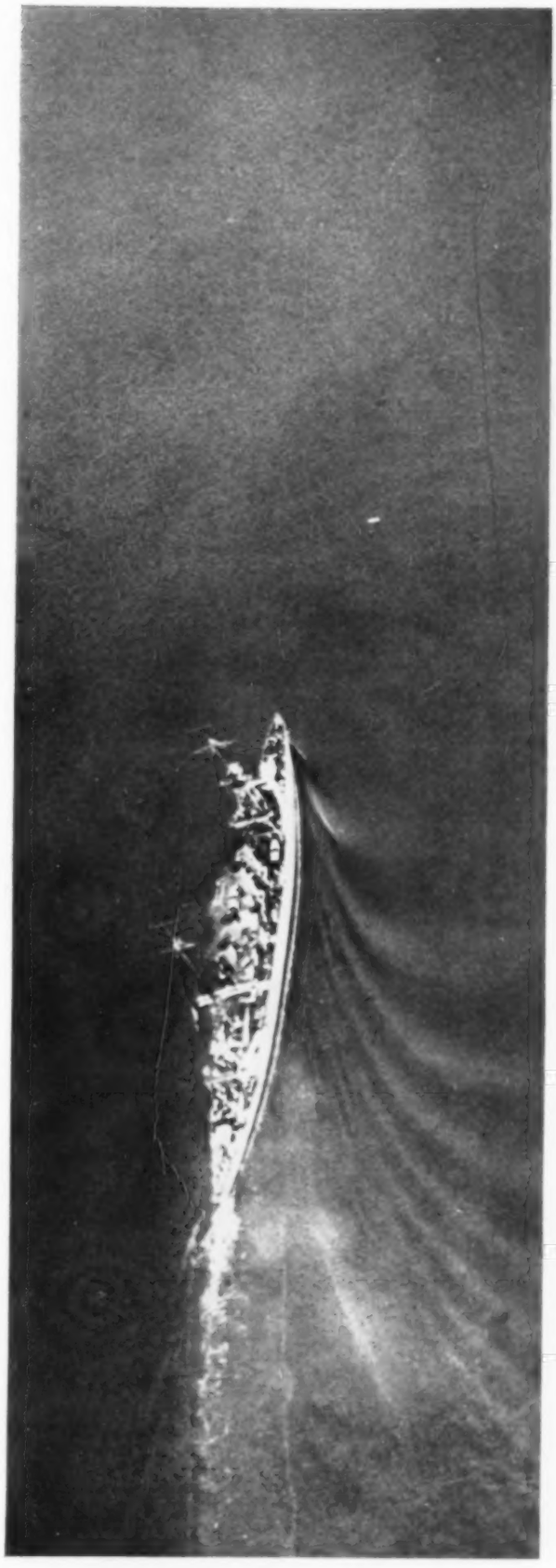
	Class 2	Class 4
Copper	0.6 max.	4.0 to 5.0
Silicon	4.5 to 6.0	1.20 max.
Zinc	0.2 max.	0.25 max.
Iron	1.0 max.	1.2 max.
Magnesium	Trace	0.35 max.
Manganese	0.2 max.	Trace
Aluminum	92.5 min.	94.5 min.

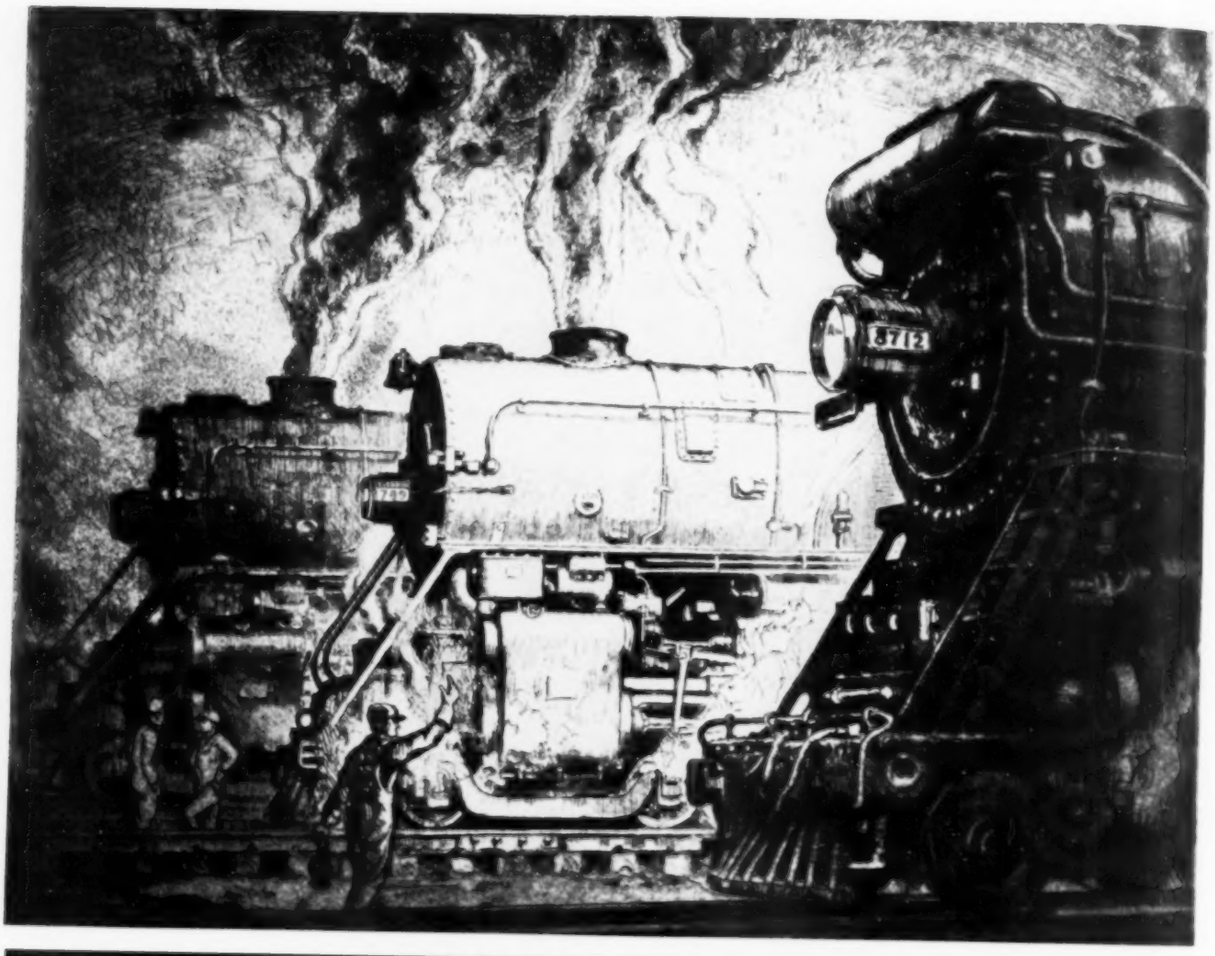
Class 2 castings must have a minimum tensile strength in standard test bar of 17,000 lb. per sq. in. and at least 3.0% elongation in 2 in. Class 4 is stronger; 28,000 tensile or more, with at least 6.0% elongation.

Aluminum Paint

As compared with oil paint, the saving in weight by the general use of aluminum paint has been considerable. Aluminum paint is used as the priming coat where color coats are applied and also as the finishing coat in lower deck spaces and storerooms. Aluminum paints made with a good vehicle are excellent for the protection of aluminum alloys, but their use is not confined to this metal alone, as they are used generally throughout the ship on steel and other materials. It is not used, however, where it is subject to contact with sea water.

This paint is made by adding aluminum powder to a suitable vehicle such as spar-varnish; the powder is in the form of microscopic flakes which overlap and furnish a continuous metallic layer over the surface of the vehicle, resulting in a film very impervious to moisture. By the use of such paint it is possible to reduce the total paint weight to approximately 50% of what it would be using an oil paint.





Reproduction of
an Etching by
Otto Kuhler

Heating and Treating Locomotive Forgings

. . . THIS RECOMMENDED PRACTICE is tentative and is to be used as a guide in the manufacture and heat treatment of locomotive forgings, such as locomotive driving and trailer axles, crank pins, main and side rods, piston rods, and similar forgings. It was adopted in January, 1931, and will remain tentative for at least one year, until adopted by the Board of Directors and the Recommended Practice Committee of the A.S.S.T. This practice is not intended for a specification and should not be interpreted as such.

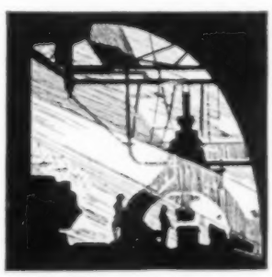
The membership of the Sub-Committee on Heat Treatment of Locomotive Forgings was as follows: J. H. Gibboney, Chairman; M. A. Herzog, J. H. Higgins, G. L. Norris, L. H. Fry, E. J. Edwards, J. A. Succop, W. M. Barr, and J. E. Donnellan, Secretary, 7016 Euclid Ave., Cleveland. Criticisms of the practice are solicited and should be directed to the secretary.

Heating Billets for Forging — As rapid heating may produce internal ruptures, care must be taken to avoid rapid heating, particularly from the low temperatures. Ample time should also be given for the heat to penetrate uniformly and thoroughly into the billet before forging. The actual heating time required will depend on the type of steel and the equipment and methods used for heating.

Cold billets should not be charged into a hot furnace. Billets that have been stored out of doors, particularly during winter months, should be brought into the shop for a warming period of 10 to 12 hr. before charging into the furnace for heating.

Preheating Forging Billets — It is good practice to preheat the billets. This preheating is best done in a separate furnace or one with a preheating chamber. If such a furnace is not available, the billets can be charged into a forging furnace after the operations for the day are completed, and the furnace has been cooled down to a dull red. The billets will absorb the furnace heat and by the next morning will be preheated to a temperature of several hundred degrees fahrenheit. The billets are then ready for direct firing, which should proceed slowly. When a separate furnace is available for preheating, the billets are charged into the cold furnace and brought up slowly and uniformly to a temperature of 1,100 to 1,200° F. The time required to heat to this temperature should be approximately 45 to 60 min. per inch of least thickness.

To avoid loss of heat, the billets should be transferred quickly from the preheating furnace to the forge-heating furnace. As the danger of rupturing the billets has been practically eliminated by preheating, the forging furnace can be at considerably higher temperature than the preheated billets. Raising the preheated billets to the forging temperature is carried out with the usual precautions to insure uniform heating



and thorough penetration of the heat. The minimum time required to bring preheated billets from a temperature of about 1,100° F. to the forging heat (2,100 to 2,200° F.) is approximately 30 to 60 min. per inch of least thickness. For billets of various thicknesses, the following schedule is typical:

Size	Time	Size	Time
8x 8	3 hr.	12x 6	3 hr.
10x10	4 hr.	14x 8	4 hr.
12x12	5 hr.	20x 8	4 hr.
14x14	6 hr.	....	....
16x16	7 hr.	18x18	9 hr.

Forging Temperatures for Billets — The proper forging temperature for both carbon and alloy steel billets, of the types generally used for locomotive forgings, is from 2,000 to 2,200° F., which is very pale yellow, fading into white. Overheating and non-uniform heating must be avoided, as both are sources of forging ruptures. It is desirable to have the heating furnace under pyrometric control, preferably by thermocouples.

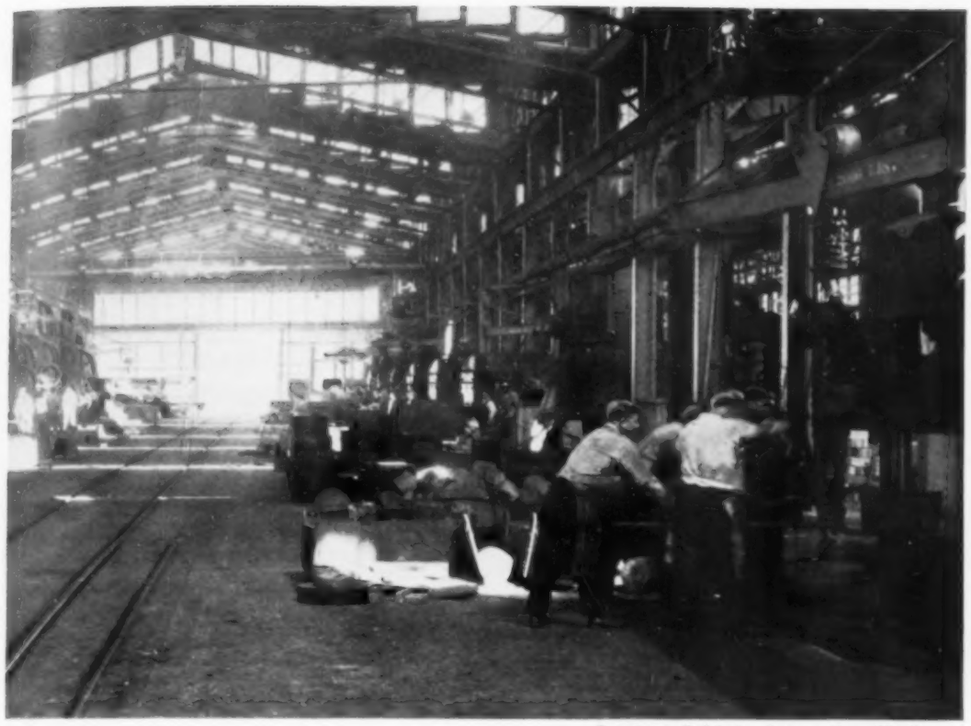
The temperature at which the forgings are finished will be determined by the initial forging temperature, and by the temperature lost during forging, which depend on the size of the forging and on the amount of work required to shape the forging from the billet. Generally they are finished at a temperature of 1,500 to 1,800° F. Lighter sections, such as connecting rods, are usually finished at the lower temperature, while heavy sections, such as driving axles, are finished near the higher temperature mentioned.

Heat Treatment of Locomotive Forgings — After the forging operation is completed, the forgings should be allowed to cool to below the critical range under suitable conditions to prevent injury by too rapid cooling. To remove forging stresses and to refine the grain, an appropriate heat treatment should then be performed on the rough forging.

Normalizing and Tempering Is Preferred Practice

The heat treatment may consist of annealing, but it is usual practice for high duty locomotive forgings, where better physical properties are required, to use a treatment consisting of normalizing, followed by tempering.

When forgings are to be bored or rough machined, they may be annealed to improve



Courtesy Baldwin Locomotive Works

the machinability, preliminary to normalizing and tempering.

Annealing — The purpose of annealing a forging is to refine the grain structure, to increase the ductility, or to soften it for ease of machining. Annealing consists of heating to a temperature above the critical range, holding a sufficient length of time at that temperature, and then cooling in the furnace or cooling under suitable conditions to secure uniform, retarded cooling.

Normalizing and Tempering Locomotive Forgings — The purpose of normalizing locomotive forgings is to refine the grain structure of a forging and to secure the highest combination of physical properties without resorting to quenching in a liquid medium. The normalizing temperature is, therefore, above the critical range. The temperature must be held a sufficient time to permit complete grain refinement in the forgings, and at a temperature sufficiently low that the grains do not coarsen after recrystallization.

Normalizing may consist of a single heating to a temperature above the critical range, followed by cooling in the air, or of a sequence of such heatings and coolings. If a sequence of heatings and coolings is used, the temperature may vary. A decrease in temperature is usually made for each successive heating, but the temperature for each heating should be above the critical range. Normalizing should be followed by tempering.

Preliminary High Heat

To eliminate the lack of uniformity in the grain structure of forgings, resulting from variations in reduction and finishing temperature, and to produce a homogeneous grain structure throughout the forgings which will respond uniformly to the usual normalizing temperature, it is often desirable, particularly with large forgings, first to normalize the forgings at a temperature much above the upper critical (approximately 1,750 to 1,850° F.).

Tempering — The purpose of tempering is to remove strains set up in the forgings during the cooling from the normalizing temperature. The ductility of the forgings is increased by tempering, while the tensile strength may be slightly reduced. Tempering is not intended to change the grain size; therefore, the temperature is below the critical range. After temper-

ing, the forgings may be cooled in the air, slowly with the furnace, or under conditions to secure uniform retarded cooling. The forgings should be held at temperature a sufficient time to insure complete penetration of the heat.

Experience Counts for Much

In annealing, normalizing, and tempering, choice as to the temperatures used, the number of normalizing treatments, the length of time that the forgings are held at temperature, the method of cooling in annealing and tempering, must be made according to experience, taking into account the type of steel, the size and character of the forgings and the condition of the furnace used.

Temperatures and Times of Heating — In view of the large number of variable conditions involved, it is impossible to lay down exact rules of procedure for annealing, normalizing, and tempering, with stated temperatures and times of heating which will be applicable under all conditions. The following general information regarding temperatures and times of heating may be expected to give satisfactory results under favorable conditions. The information is given only as a guide and not as standard practice for all cases. Experience based on the actual conditions involved will sometimes show that better results are obtained by the use of other temperatures.

The rate at which forgings are heated to the normalizing and tempering temperatures must not be too rapid or the forgings may be injured. The proper rate will depend to a considerable extent on the design of the furnace. In general, the time allowed for each inch of diameter or thickness of the forging should be 45 min. for raising to the normalizing temperature and 30 min. for raising to the tempering temperature.

After the temperatures desired for normalizing have been reached, the forgings should be held at these temperatures a sufficient time to permit the desired changes in structure to be completed. In general a holding time of one hour per inch of diameter or maximum thickness will usually be satisfactory.

The following is a general guide for the approximate heating and holding time for a medium furnace charge of forgings.

Thickness of Largest Section	Time of Heating	Time of Holding
Up to and including 5 in.	8 hr.	5 hr.
Over 5 in. and including 8 in.	8	8
Over 8 in. and including 10 in.	10	12
Over 10 in. and including 12 in.	12	16

Normalizing and Tempering Temperatures — The tabulation printed on this page gives, for general guidance, temperatures which may be used in normalizing and tempering forgings of the various compositions indicated. Figures are based on a single normalizing treatment with slow cooling in the furnace from the tempering temperature. As previously stated, the temperatures may require modification to meet individual requirements.

Annealing temperatures will usually be lower than the normalizing temperatures. The difference is approximately 50° F. lower for annealing the plain carbon steels, 25° F. for the nickel steels, and 100° F. for the vanadium steels.

DATA FOR NORMALIZING AND TEMPERING LOCOMOTIVE FORGINGS

Chemical Analysis					Normalizing Temperature	Tempering Temperature	Approximate Tensile Strength
Carbon	Manganese	Silicon	Vanadium	Nickel			
0.40 - 0.45	0.50 - 0.85	0.18 - 0.30	-	-	1,500 - 1,550	1,000 - 1,100	80,000
0.45 - 0.50	0.50 - 0.85	0.18 - 0.30	-	-	1,475 - 1,525	1,100 - 1,250	80,000
0.50 - 0.55	0.50 - 0.85	0.18 - 0.30	-	-	1,450 - 1,500	1,200 - 1,350	80,000
0.45 - 0.50	0.70 - 0.95	0.18 - 0.30	0.15 - 0.25	-	1,600 - 1,650	1,050 - 1,200	95,000
0.50 - 0.55	0.70 - 0.95	0.18 - 0.30	0.15 - 0.25	-	1,575 - 1,625	1,150 - 1,300	95,000
0.35 - 0.40	0.50 - 0.80	0.18 - 0.35	-	3.25 - 3.75	1,425 - 1,475	1,000 - 1,150	90,000
0.40 - 0.45	0.50 - 0.80	0.18 - 0.35	-	3.25 - 3.75	1,425 - 1,475	1,050 - 1,200	90,000
0.20 - 0.30	0.80 - 1.00	0.18 - 0.35	-	2.50 - 3.00	1,425 - 1,475	1,000 - 1,200	80,000

Polishing Hard Carbides On Diamond Lathe

By W. A. WISSLER
Union Carbide & Carbon
Research Laboratories

• • • WHENEVER a study of tungsten carbide is initiated, one of the first requirements is a method for preparing metallographic samples. When this need arose, some years ago in the Union Carbide & Carbon Research Laboratories, Long Island City, N. Y., discussion with several gentlemen familiar with the gem stone industry resulted in the decision to visit one or more of the diamond cutting establishments in New York City.

Most gem cutting is done by people of Dutch or Belgian descent, many of whom learned the trade in Holland and came to New York to carry on their work. The several diamond cutting establishments visited consist of one or possibly two small rooms in which one or two men are at work on diamond cutting lathes; often, especially in one-man establishments, part of the room has been blocked off into living quarters.

On the first visit I ran up against a steel grid door, through which the initial talking must be done. Upon explaining that I had a few samples of metal to be polished, I received a reply approximately, "Metal — we don't want to bother with it; take it out to a polishing shop and get it done!"

However, I argued the point with him and explained that this material was too hard to be worked by any other method, and also pointed out that the job would be paid for. As times were rather dull at that moment I was permitted to enter through two sets of barred doors into the workshop. It consisted of a space about 12 ft. square.

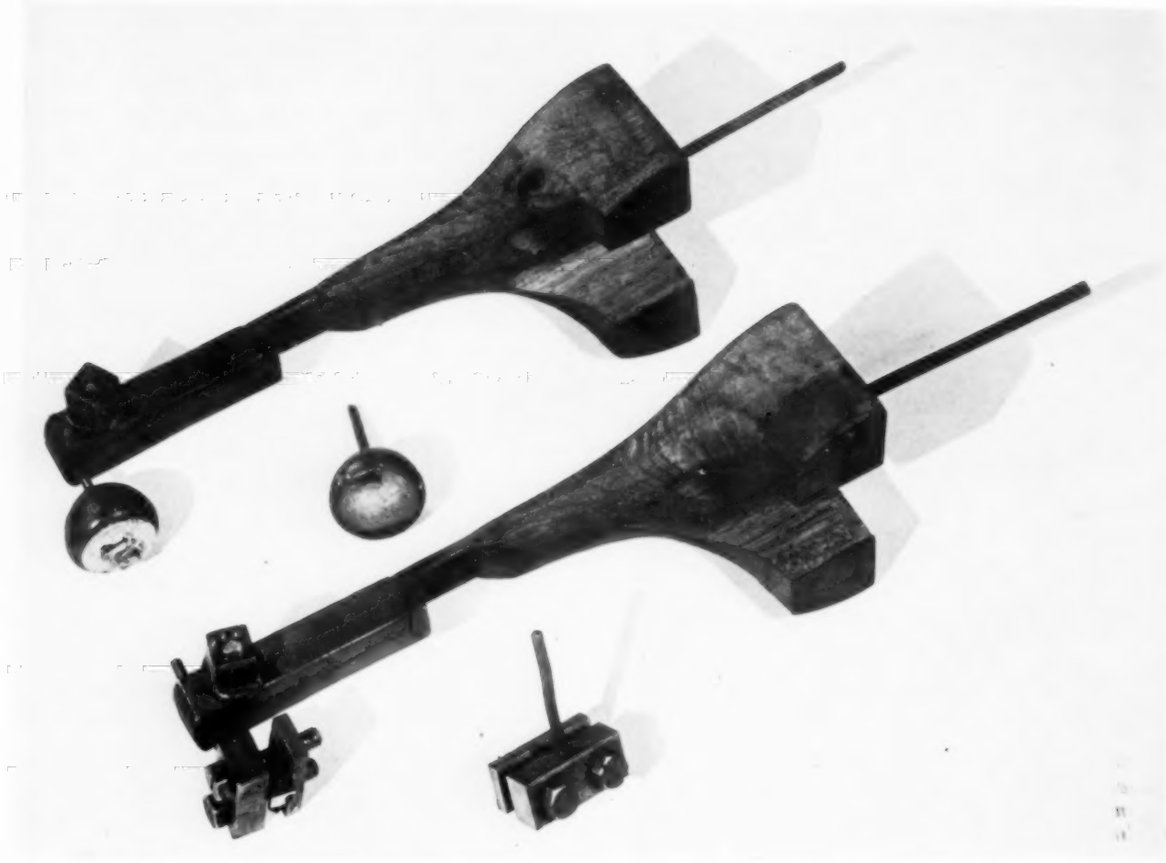
One of the two occupants was at a polishing lathe cutting faces on a pair of matched triangular diamonds. The triangles measured about $\frac{3}{8}$ in. on a side, and I afterward found that these particular faces had been on the polishing disk for two or three days and were not as yet finished.

The man in charge rather contemptuously took one of the pieces of metal I had with me and held it against the wheel for 10 or 15 seconds, after which he took it away and looked at it, presumably expecting to have already ground a nice flat surface. Upon finding that the surface was scarcely touched he immediately changed his attitude and became greatly interested in the product, and from then on as long as he continued to do our work we had no further trouble and we were always welcome.

Similarity to Diamond Cutting

The procedure for polishing tungsten carbide was the same as was being used on diamonds. The sample was placed in a "dopp", which is a copper or bronze cup about half the size of a small wine glass. Fastened on its bottom, as a handle, is a copper wire about $\frac{1}{8}$ in. thick — the assembly roughly resembles a partly opened tulip. The dopp is filled with a low melting point alloy.

Mounting procedure consisted in warming the metal with a gas burner, pushing the sample or diamond into the mushy metal, and shaping the metal around it by pressing or wiping with



Diamond Cutter's Dopp (the Small Cup) Is Filled With Fusible Alloy In Which Is Fixed Super-Hard Metal or Carbide Samples. A modification for use with squared pieces is also shown. The skein of copper wire may be slightly bent to get the correct angle with surface of polishing wheel

a piece of leather. This having been done, the dopp is fastened by its stem into a fixture which acts more or less like a man's forearm — that is, if the elbow is resting on the table. The dopp assembly is held on the table by being laid between two upright pins that prevent it from spinning with the wheel, although it is free to be moved radially. These features are clearly shown in the general view on this page.

Construction of Wheel

The wheel is made of a special cast iron mixture, and the finished part is usually imported from Belgium. It is about half an inch thick and 12 in. diameter, carefully balanced on a shaft having points at each end that fit into wood blocks for bearings. The disk is driven by a belt and runs very steadily without any detectable vibration. When new it is prepared by having diamond dust and olive oil rubbed into its surface, and the same mixture is occasionally added during the course of operation.

Each diamond cutter has what he calls a "finish" band on the wheel, which is a circular section that he uses only for securing a very high finish. The roughing work is done on other annular bands or rings on the surface of the same wheel.

One of the surprises met in my contacts with diamond cutters was the fact that none of the shops I visited had any means of measuring angles. My impression is that the angles on gem stones instead of being as exact as is generally believed, depend somewhat upon the position of flaws that are always present in the rough stone. Undoubtedly the skill of the diamond cutter enables him to reproduce angles rather closely, but nevertheless none of the several shops had any protractors, even the crud-

est, and none of them seemed to know how to go about measuring angles if they had wanted to do so.

Another surprising item was the relatively small amount of diamond dust that is required for the work. This material is of course rather expensive, costing at the present time $4 to $5 a carat. It is made by crushing chips or small stones that can be bought at somewhat under $2 a carat, but the cost of pulverizing and sizing, and the rather heavy loss that occurs during this operation, undoubtedly justifies the spread between the price of the raw product and that of the powder.

We have experimented with various powders aside from diamond, but find that for metallographic work the latter is so much more rapid and efficient in cutting and polishing that it does not pay to use cheaper polishing materials. This does not mean that we would recommend diamond powder for commercial lapping of hard carbide tools, although there is considerable reason to believe that diamond dust might be the most economical for tool room work, in spite of its high cost.

Periodically the diamond cutter's wheels are scoured. I have never seen this done but was led to believe that it is actually a scrubbing operation, the purpose being to clean the wheel and put it in condition to be built up anew with diamond powder. A good many of the shops send their wheels out to be scoured by people who specialize in this line and who are believed to have worked up methods of recovering some of the diamond dust scoured off the wheel, but I cannot vouch for this rumor.

These small diamond cutting shops handle their business along two lines — one is to cut to order any rough stones, or to recut any gem stones that are brought to them by retail or wholesale jewelers. They also, whenever possible, buy rough stones, which they cut and sell.

As a result of these experiences, the Union Carbide & Carbon Laboratory installed a lathe of the same type as used for gem stones. The dopps were found unsatisfactory, and the simple clamp shown opposite was devised.

Diamond Cutter's Lathe Used for Preparing Metallographic Specimens of Hard Carbide Materials. The revolving plate is accurately mounted on centers between hard-wood bearing blocks, and is belt driven by motor underneath table top. Dish at rear contains diamond dust in oil, and a small strip of leather for applying this abrasive to the wheel

Method of Rough Grinding

Samples are prepared for the diamond lathe by being ground in the regular way — which consists of using silicon carbide grinding wheels having a soft bond, and run at low speeds — by which means a fairly good surface is obtained. Final polish is given on the wheel, using No. 9 diamond dust mixed with olive oil, (or sometimes turpentine), and requires a period of from 15 min. to 3 or 4 hr., depending mainly upon the condition of the surface prepared by grinding. Lapping requires no attention other than an occasional examination of the surface.

As an etching reagent, an alkaline solution of ammonium persulphate has been used — it attacks the ground mass of the cast carbides. In some instances it has been advisable to give a short final polish with alumina on broadcloth, which treatment brings out slightly more relief.

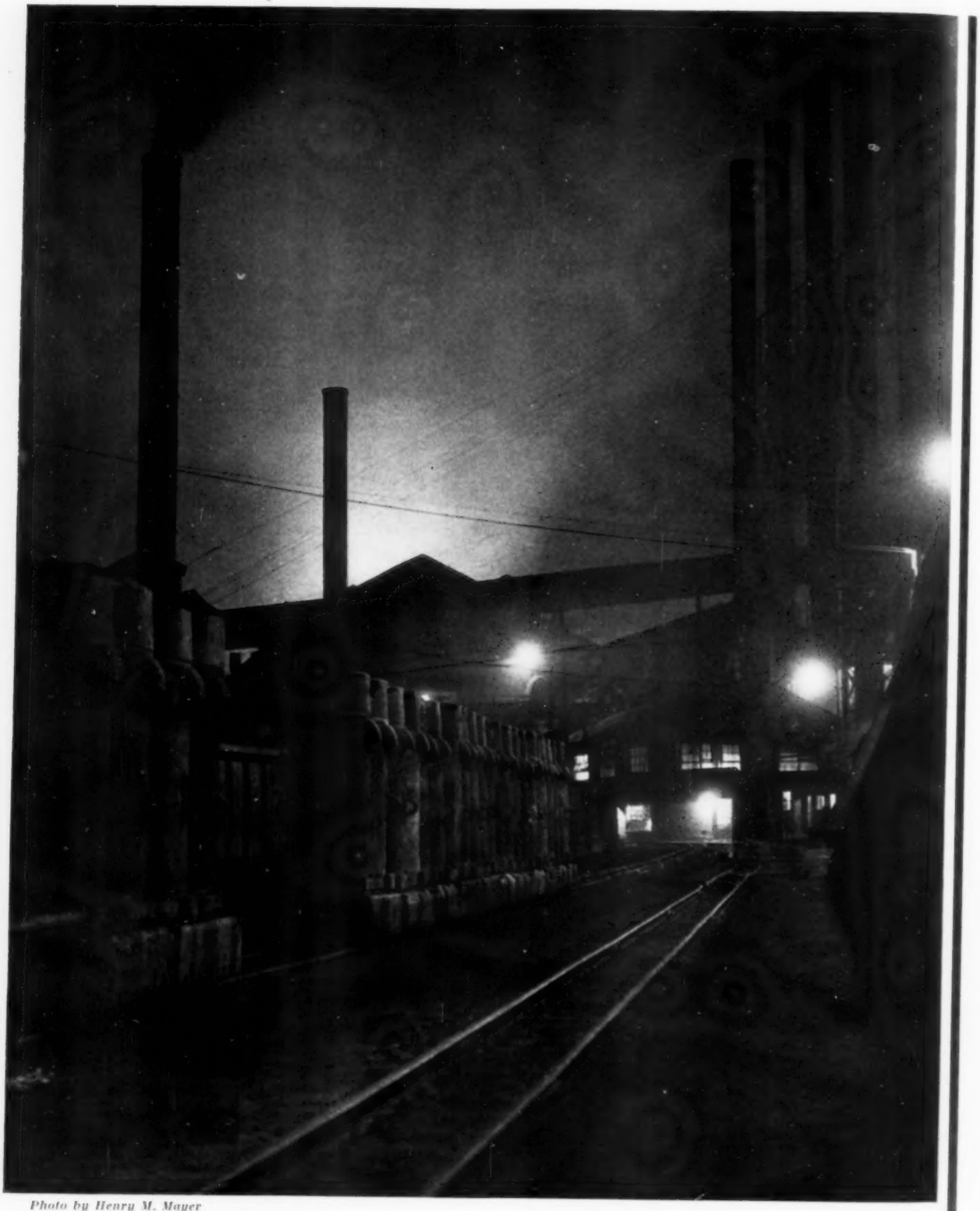


Photo by Henry M. Mayer

Nocturnal Fires

Constant Care Needed in Alloy Steel Manufacturing

•

By A. D. SHANKLAND
SUPT. OPEN-HEARTH DEPT.
Bethlehem Steel Co.

• • • ALTHOUGH alloy steels were known before the advent of the automobile, the need of lightness in automotive parts, together with strength and resistance to shock, is responsible for their widespread use today. It may therefore be said, safely, that the development of the automobile and alloy steels have gone hand in hand. With the rapidly increasing use of the airplane for commercial and passenger service, the demand for steels of still greater strength and resistance to fatigue is becoming more and more pressing. This is due not only to the fact that the need for lightness is more imperative than in the automobile, but that the results of a failure are usually more disastrous.

It is safe to predict that the next few years will see not only the development of new alloy steels but also higher physical properties obtained from present compositions. It is, therefore, fitting that we discuss at this time the method of manufacturing basic open-hearth alloy steel. I mention the basic open-hearth process because by far the larger percentage of alloy bar steel is melted by this method.

Methods of manufacturing alloy steel vary with the individual manufacturers as to details of operations, but I believe that there are a number of basic rules or methods of procedure which are generally accepted and applied. It is my intention, therefore, to describe the general practice of manufacturing alloy steels, pointing out as I go along, the reasons for various procedures.

Before going into a discussion of the operating details, I feel that attention should be called to the fact that alloy steel making is a specialty business and in a class by itself, which is entirely foreign to and apart from the usual tonnage methods employed in the manufacture of other commercial steels.

Another point worthy of emphasis is the following. In order that the steel maker may keep alive to the changing applications in the customer's plant and may have first hand information which will permit him to give each type of steel the attention required to insure its being satisfactory for the customer's requirements or application to a particular part, it is necessary for him to maintain a staff of trained metallurgists in contact with his customers. The more detailed the information this staff can obtain about past difficulties and current performance, the more satisfactory will be the product furnished to the customer. These contact men are often of valuable assistance to steel consumers in solving many of their problems. Their function is one of service to both producer and consumer.

The first step in the manufacture of a quality product is the selection of proper raw materials. Since we shall follow the manufacture of alloy steel from the open-hearth charge to finished bars, I shall discuss the raw materials as applied to the open-hearth operation.

Pig Iron. The effect of certain elements should be considered in the selection of the iron used, but the most essential requisite is that the composition of the iron shall vary as little as possible from day to day. A high percentage of

Fine Steels Require Utmost Cleanliness in the Casting Pit. Therefore, ingot molds are carefully swept up with vacuum cleaner pipe, after hot tops are set and just before heat is ready to be teemed

manganese is desirable, not only due to the fact that this element is an ideal desulphurizer, but also because it protects the bath from over-oxidation.

The sulphur content is not important if a high percentage of manganese is simultaneously carried in the iron.

An abnormally low silicon content is objectionable due to the fact that a greater percentage of iron is required in order to have the desired carbon in the bath when melted. An abnormally high silicon content is objectionable due to the corrosion of the basic banks by the acid silicon dioxide formed by its oxidation and elimination, the higher percentage of lime required to neutralize the latter, and to the danger that phosphorus may revert to the bath during the refining operation.

Scrap. For the manufacture of alloy steel it is desirable to use the best scrap obtainable. This scrap should be specially selected and of known analysis, because any alloys it contains will be either beneficial or detrimental.

To illustrate: Nickel or nickel-chromium scrap can be used to advantage in making nickel-chromium steel, but the nickel would be objectionable if this scrap is used in a chrome-molybdenum or chrome-vanadium heat.

Fuel. No matter whether oil, gas or tar is burned, it should be of the highest calorific value obtainable and as low in sulphur as possible.

Limestone should be as high in lime and as low in silicon and magnesia as possible. The reasons are obvious.

Ferroalloys. To insure obtaining high quality ferroalloys, it is well to purchase them from a reliable manufacturer.

I do not wish to be understood as stating

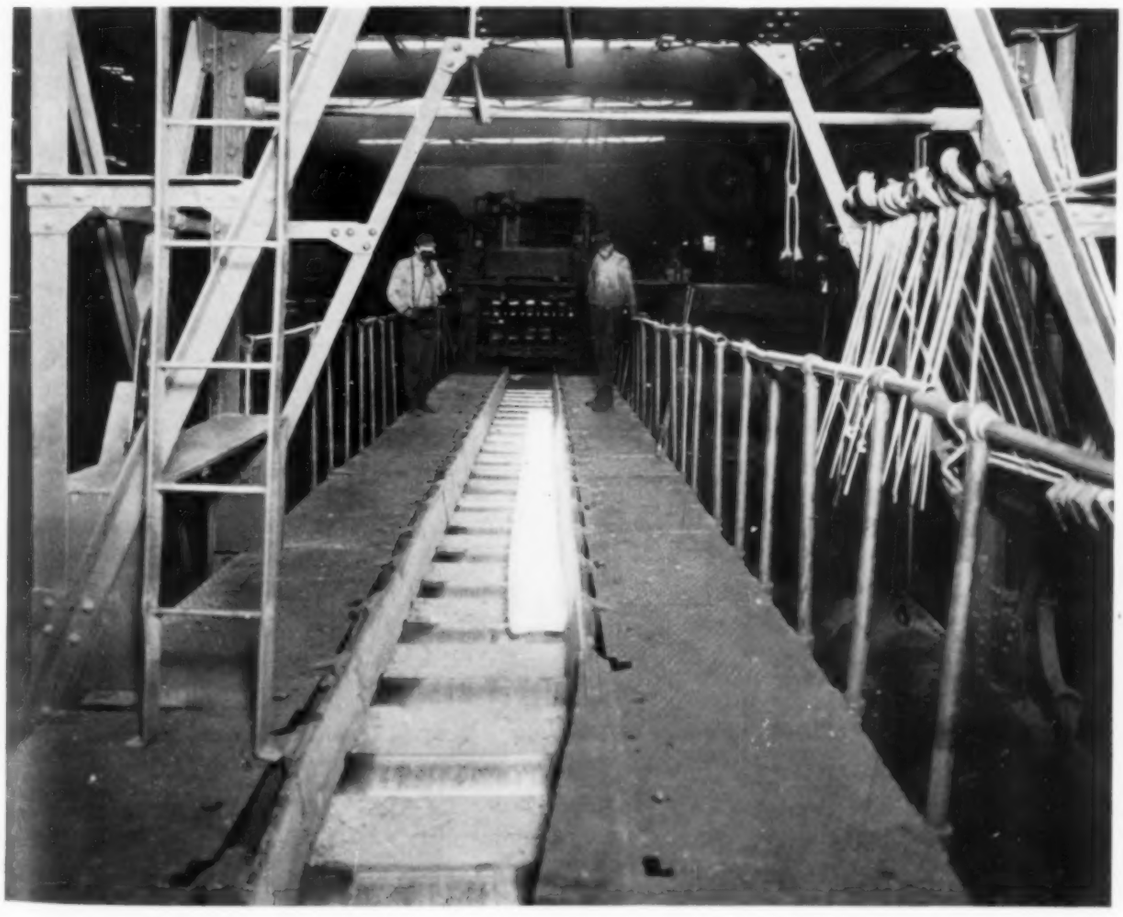
that it is impossible to produce good alloy steel from inferior raw materials. On the other hand, I know that steel of good quality can be made from raw materials which are not up to standard, providing they do not contain chemical impurities which cannot be eliminated. It is, however, much more difficult and costly to produce a quality product from inferior raw materials and the chances of tapping a heat which has not been properly cleaned up are greater. Therefore, the alloy steel manufacturer generally advocates the use of high grade materials.

As an aid to a more thorough deoxidation of the bath and also as insurance against the reversion of the phosphorus from the slag while refining the heat, it is customary to charge approximately 12% of limestone on all heats of alloy and special carbon steels for forging. This additional limestone materially prolongs the time of each heat and shortens the life of the furnace. Similar and cumulative effects are felt from the necessity for thoroughly deoxidizing the bath. However, in these as in all other operations in the manufacture of alloy and special steels, quality is the first consideration.

Final deoxidation of the heat is usually accomplished by the addition of either spiegeleisen, 14% ferrosilicon, or a combination of these alloys. After the additions are made the bath is allowed to come back on a boil and it is then rekilled with either of the above mentioned alloys or some other alloy of a similar nature. The aim of the melter is to use that combination of ferroalloys which will most thoroughly deoxidize the bath, and at the same time form the most readily fusible slag.

The bath is allowed to "open up" between the first and second deoxidizing additions in or-

Temperature in Soaking Pit, Degree of Reduction in Each Pass of Blooming Mill, and Finishing Temperature Are All Matters Which Must Be Carefully Controlled When Manufacturing Alloy Steel



der to aid the products of the deoxidizing reaction to free themselves from the bath and rise into the slag. The second deoxidizing addition is made to hold the carbon content constant and to deoxidize the bath further.

If the carbon content has been found by analysis to be satisfactory, the final alloy additions such as ferrochrome and ferromanganese are then made and the heat is tapped. Ferrosilicon and ferrovanadium (in a vanadium heat) are added in the ladle.

Nickel and *ferromolybdenum* are added in the furnace. They can be added at any stage of the heat, due to the fact that there is practically no loss from oxidation. It is well to get these metals in early, so that the melter's entire attention can then be given to other factors.

Ferrochrome is added in the furnace approximately 20 min. before tapping.

Ferromanganese is added in the furnace approximately 10 min. before tapping.

Ferrosilicon is added in the ladle instead of in the furnace, for the following reasons: (a) The SiO_2 formed has a corrosive action on the basic banks of the furnace; (b) To avoid the danger of reversion of phophorus from the slag to the steel; and (c) To avoid excessive loss of silicon, which is readily oxidized.

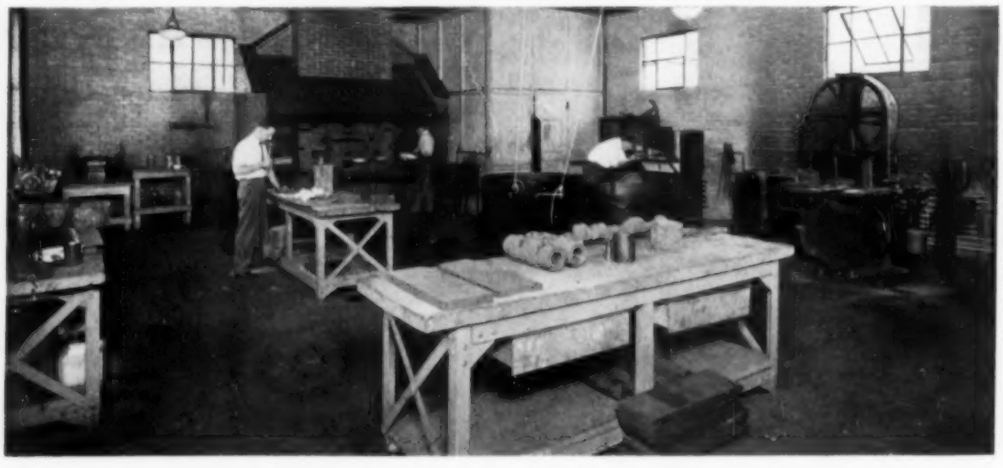
Ferrovanadium is added in the ladle, due to the affinity of vanadium for oxygen, which would also result in excessive loss if added before it is necessary.

Pit Practice. Not so many years ago it was a generally accepted belief that if steel is properly made in the furnace and poured without a running stopper, the quality must be satisfactory regardless of the balance of the pit practice. Experiments in recent years have shown that mold design, mold temperature, teeming temperature of the steel, cleanliness of the molds and protective coating on the mold walls, are equally as important as good furnace practice.

The molds into which the steel is poured should be "large-end-up," of the proper contour, proper ratio of length to diameter and equipped with a good clean type of hot-top in order that the steel may be sound and free from excessive segregation and porosity after the top discard has been taken. The molds should also be thoroughly cleaned and covered inside with some coating which will throw back the splash and wash of the metal, as well as prevent any reaction between the steel and the oxidized surface of the mold. Tar, graphite, aluminum and similar coatings are used.

Ingots should then be charged into the soaking pits and heated very carefully so as to get a thorough soaking, without overheating. As in the teeming operation in the open-hearth, the proper rolling temperature varies with the grade of steel.

Due to the fact that both the special carbon and alloy steels are more dense than commercial steels it is necessary to take lighter draughts and turn the bloom more frequently while rolling. After rolling, it is necessary to retard the cooling of the blooms and billets of higher carbon alloy steels or those which are rich in alloy



Metallurgical Laboratory, Located Next Door to Alloy Mill and Heat Treat, Is Continually Making Quick Tests to Check the Quality of Metal Going Through

Alloy Steel Billets Require Slow Cooling In Covered Pits or Otherwise, Especially If They Are of the Air-Hardening Types

content. This is done either by placing them in cooling pits or burying them in ashes or some other insulating material.

It is desirable to determine as soon as possible the fitness of the heat for the customer's application. It is, therefore, customary to ascertain this on the billets or blooms by means of the hot acid etch, Ehn test, microscopic examination or any other test which will give this information. In the event that these preliminary tests show the heat to be unfit for the purpose intended, it is either diverted, or scrapped and remelted. As a result of the extreme precautions taken in all operations, remelting is seldom necessary.

The greater density of alloy and special carbon steels makes them more susceptible to surface defects. These defects are removed either by grinding or chipping, depending on the composition of the steel and also the purpose for which the finished bar is intended. Frequently, pickling is resorted to, in conjunction with chipping, in order to reveal the minor surface defects. Whether or not this is done depends upon the purpose for which the finished bar will be used and also on the results of a preliminary examination of the billets.

The billets are now rolled on the finishing mills where the same attention is given to temperature control as in the soaking pits and open-hearth teeming operations. Coupons are taken from the finished bars at the shears and submitted to a number of tests to determine the fitness of the material for the customer's requirements. In the event that the tests are completely satisfactory the steel is ready for shipment; otherwise the heat is either given a subsequent processing to place it in proper condition for the customer's use or it is bench inspected and the unsuitable material removed and scrapped.

All of the above-mentioned operations should be, and generally are, supervised and inspected by representatives of a central metallurgical organization who are independent of the operating organization. The following is a typical line-up:

Open-Hearth. Metallurgical observers on each shift who supervise and report on all operations from charging the furnace to shipment of ingots.

Soaking Pits and Blooming Mill. Observers who supervise the heating and report any irregularities in heating or rolling.

Billet Yard. Supervision by inspectors of chipping, from the standpoint of customers' requirements.

Preliminary Testing. The preliminary etch and metallographic tests on billets, as outlined above, should be under supervision of a metallurgical inspector.

Mill Inspection. Inspectors on all mills have power to hold up production in the event of unsatisfactory quality.

In addition to the above, there should be a laboratory located adjacent to the operation which is equipped not only to handle the testing necessary to insure uniform quality in the product, but also for experimental research in the development of higher quality.

Although this paper endeavors to present a picture of the various steps in the manufacture of alloy steels as carried on to-day, with the ever-increasing demand on the alloy steel manufacturer for higher quality, I would hesitate to predict the procedure which will be in use a year or two hence!

Ups & Downs of Titanium

By G. F. Comstock
Consulting Metallurgist

. . . In the very early days of chemistry before many of the elements were recognized, an English scientist named McGregor was investigating a magnetic sand in Cornwall, and reported the existence in it of a new element, which he called "Menachin" after the locality of its occurrence.

There was no Metal Progress at that time, however, to keep people informed up to the minute on new developments, and this report of McGregor's did not seem to receive due recognition. For, a few years later, a certain M. H. Klaproth, in describing the mineral rutile, called the metallic element in it Titanium, presumably on account of his admiration for the super-strong Titans of old mythology, and in 1797 admitted that it was the same thing that McGregor had discovered. In spite of the latter's undisputed claim to priority, the original name was soon forgotten, in favor of the better-sounding titanium.

It was many years after this, in fact over a century, before this element was really isolated in anywhere near a pure condition so that its properties as a metal could be studied. Wollaston in 1823, Berzelius in 1825, Wohler in 1849, Nilson and Petersson in 1887, and Moissan in 1895 were some of those who, in studying the properties of what they considered to be metallic titanium, actually succeeded in preparing only various mixtures of the metal with its oxide, nitride, or carbide. It is not surprising therefore that the results reported were contradictory and confusing.

Hunter, in 1911, probably produced the purest metal that had been studied up to that time and found that beads could be forged into rods at a red heat, though they were brittle when cold. There is some slight doubt as to the purity of even his metal, produced by reduction of the chloride with metallic sodium. A metallographic examination by the writer seemed to show a duplex structure, leading to a suspicion of contamination by sodium. Van Arkel and Boer in 1925 described a ductile titanium metal in the form of wire which they produced by distillation of the iodide in a vacuum.

But the properties of metallic titanium are not of great practical interest to us today, because of the difficulty of preparing this metal. If a good method for making it, in even a reasonably pure state, is ever developed, this condition may be changed; uses may be found, and its properties become well known. For titanium is not really a rare metal. Very large deposits of its ores are known, chiefly in the form of the oxide mixed with iron oxide, and more is said to be available in the earth's crust than of any other metal except silicon, aluminum and iron. The present interest in titanium is due to a growing realization of the abundance of its compounds in nature, and especially to the development of wider uses for them so that more people are coming in contact

with the element in one form or another.

Forty or fifty years ago almost the only attention paid to titanium in a practical way was by operators of iron blast furnaces, most of whom were only interested in keeping it out of their furnaces. A strong feeling existed among these men, and indeed still exists in some quarters, that the presence of much titanium in the ores would result in the formation of viscous slags and deposits of infusible material in the hearth, so that operation of the furnace would soon become impossible. There was undoubtedly some justification for a part of this opinion, since the formation of copper-colored titanium cyano-nitride in blast furnace hearths is a rather common occurrence, and it is certainly quite infusible; but the slags can be adjusted so as to be fluid even with high titanium contents.

The Name of Auguste J. Rossi is Inseparably Connected With the Titanium Industry of the United States. For his indefatigable labors on the problem of commercial utilization of titanium he received the Perkin Medal, highest honor bestowed by American chemists

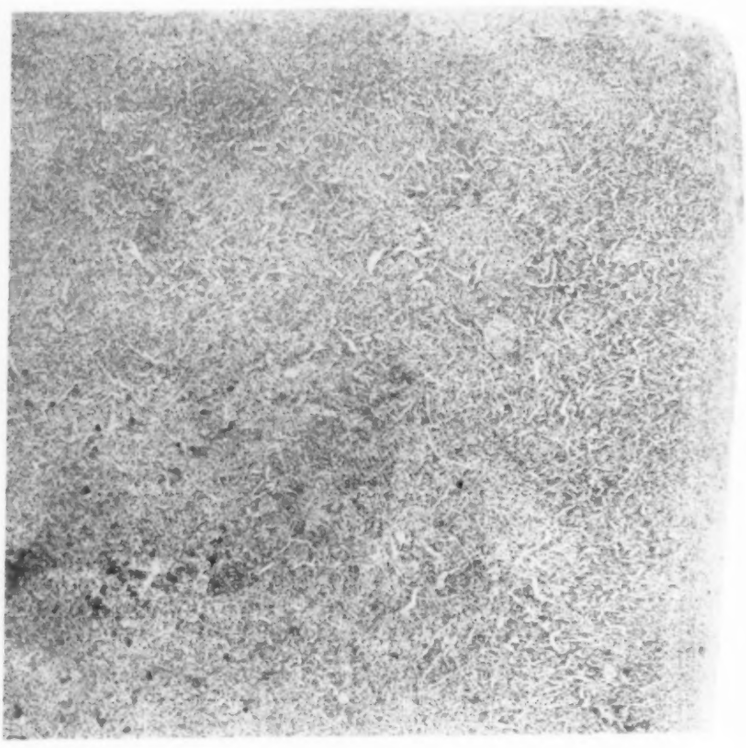
Auguste J. Rossi of New York, recipient of the Perkin Medal of the Society of Chemical Industry in 1918, came forward about 1890 as the champion of titaniferous iron ores, and showed by practical experiments that they could be smelted easily by proper adjustment of the blast furnace charge, giving excellent iron and fusible slags.

From the rather voluminous literature on the subject of smelting titaniferous iron ores in the blast furnace, it is really difficult to understand how the idea that titanic oxide makes the blast furnace slags infusible could have originated, unless it was due to unrecognized cyano-nitride formation. Data have been published showing good fusibility for slags containing as much as 36% titanic oxide, and with silica ranging from 15 to 40%, lime from 6 to 33%, alumina 9 to 18%, and magnesia 1 to 12%. Some Canadian engineers have claimed that titanic oxide should be considered as a base in such slags, thus making the silicious titaniferous ores practically self-fluxing; while others, who have actually made successful blast furnace runs with them, have considered the titanic oxide as an acid, and added lime for fluxing in the usual way. Both found the resulting slags to be readily fusible and fluid. It seems generally recognized that the presence of considerable magnesia in these slags is advantageous.

As early as 1868 a Dr. Forbes in England successfully smelted titaniferous iron ores for several years; another better-known instance of their successful utilization was even earlier, around 1850, in the Adirondack Mountains of New York. The slags made there contained about equal quantities of silica, lime, and titanic oxide, and were sufficiently fluid. Futhermore the iron marketed had an excellent reputation, and the business was discontinued only because of the inaccessibility of the furnace and transportation difficulties.

A more authoritative demonstration of the possibility of smelting titaniferous ores was provided by a run in the blast furnace at Port Henry, N. Y., and reported by F. E. Bachman before the American Iron and Steel Institute in 1914. The slags made there, containing up to 18% titanic oxide, were very fluid, but a little trouble from infusible accretions in the furnace

Sulphur Prints of Billet Steels of Same Chemical Composition and History, Except That Cleaner Steel Was Titanium Treated. Reproduction is at full size; a little more than one-quarter of the cross section is shown so the axial segregation is plainly evident



was noticed. This was probably due to nitride formation, and was kept from becoming serious by changing the burden periodically to non-titaniferous ores.

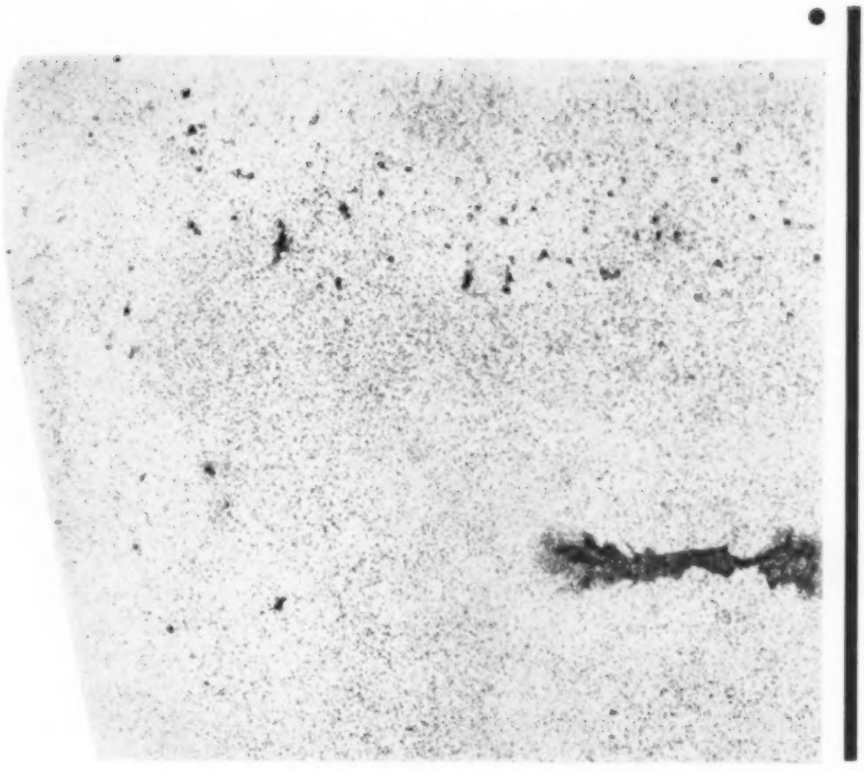
The reasons for so much interest in the successful treatment of titaniferous iron ores is because they exist in enormous masses, are rich in iron, and generally low in such undesirable impurities as phosphorus and sulphur. Some of the best-known localities for these ores are in Norway and Sweden; in the Adirondacks of New York state; at Iron Mountain, Wyoming; at Baie St. Paul and Ivry, Quebec; in Virginia, where the ore is mixed with a phosphate but can be rather easily separated; and, in the form of beach sands, in Florida, India, New Zealand, and Japan. The utilization of these sands has provoked considerable research, and they seem better adapted for uses other than blast furnace smelting. The deposits in New York and Wyoming, however, consist of very pure and rich ore that can readily be separated magnetically from much of the titanic oxide, and will undoubtedly be used for the production of iron before many years.

In the course of Dr. Rossi's experiments with the smelting of titaniferous iron ores, he became impressed by the excellent quality of the iron produced from them, and decided to see if a "concentrate of titanium," as he called it, could not be made, so that by its addition to any iron, the high quality of a titaniferous iron might be conferred upon it. To reduce the titanium from its ore in the desired concentration he was obliged to resort to the electric furnace, and in this way the manufacture of ferrotitanium was commenced in 1900 at Niagara Falls.

Dr. Rossi did an enormous amount of work on titanium compounds of various kinds, and took out numerous patents on them. Among the more useful products that he developed were ferrocarbon-titanium, made by reducing titanic oxide with carbon, and a low carbon ferrotitanium made by reducing the ore in a bath of aluminum heated by the electric arc. The latter alloy, although practically free from carbon, always had a considerable content of aluminum beside the titanium, and was not considered as promising as the other. Any account of the status of titanium, even such a brief one as this, must draw heavily on Dr. Rossi's papers, patents, and addresses.

At about the same time in Essen, Germany, Dr. Hans Goldschmidt, the inventor of the thermit process of welding, brought out a similar low-carbon ferrotitanium containing aluminum, but made by his aluminothermic process. This process is carried out by mixing powdered aluminum with the ore of the metal to be reduced, and heating the mixture to the temperature required to start the reaction. When once started, a large amount of heat is developed by the burn-

ing of the aluminum, which takes the oxygen from the other metals in the charge and leaves them in the form of an alloy, covered by a slag of alumina.



For several years around 1910 there was quite a controversy in the technical press as to the relative merits of the ferrocarbon-titanium made by Rossi's process, containing 17% titanium and 7% carbon, and the low carbon ferrotitanium advocated chiefly by the Goldschmidt Thermit Co., and containing about 25% titanium and 6% aluminum. The argument was never decisively settled, and the final outcome was that both alloys found their special fields of usefulness. The relative costliness of the low carbon alloy, as well as its content of aluminum, were factors that tended to keep its volume of production below that of ferrocarbon-titanium. When the former, for instance, was selling for 25¢ per pound, the latter could be bought for about one third as much.

Dr. Rossi's original idea in devolping the ferrotitanium alloys was, as noted above, to incorporate in iron and steel the good properties that he had noticed in titaniferous cast iron. But the actual result of his work was somewhat different.

Little Titanium Remains In the Steel

When steels came to be treated with his alloys, and were examined and tested, it was soon found to be very difficult to get any significant amount of the titanium to remain in the steel. This does not mean that no results were obtained from the treatment. Had that been the case, there would have been no market for titanium alloys, no interest in this element among metallurgists, and no excuse for the present article in METAL PROGRESS.

What did happen was that the titanium treated steels were found to be better deoxidized and cleaner than the ordinary steels made at that time, and the true function of titanium in steel came to be recognized as that of a scavenger or remover of impurities, rather than as a true alloying element conferring special properties due to its presence. On that basis a large amount of ferrocarbon-titanium was used about 1910 to 1915 in rail steel, and it became well known in the industry.

Rails made during the five years noted gave a very good service record. Average failures per year in service per 100 track-miles, as reported by American Railway Engineering Association, range from 3.3 to 6.8, (compare similar figures of 8.7 to 26.2 for contemporaneous records of non-treated rails).

Reason for this superior performance may be ascribed partly to the fact that steels properly treated and containing a small residual content of titanium give notably cleaner sulphur prints. Ample evidence is at hand to prove that the examples illustrated on these pages represent what may be expected, and are not "specimen ex-

hibits." For instance, samples from 212 rail steel heats were studied for segregation by analyzing drillings at center and corner of head (standard test procedure). Results follow:

	Plain Steel	Treated Steel
Less than 1% segregation..	6	29
Segregation 1 to 12%.....	34	65
Segregation 12 to 20%.....	27	5
Segregation over 20%	44	2
Total heats	111	101

The technical literature on titanium in iron and steel is quite extensive, and many papers have appeared, especially in Europe, dealing with the effects of additions of this element. No attempt will be made to cover this subject now, nor even to present the conclusions that have been drawn by the writer from his own work along this line. These have been published elsewhere, and a summary is given on page 237 of the National Metals Handbook, 1930 Edition. Reference may also be made to a paper on titanium by A. Thompson, carried in the magazine section of *American Metal Market*, September, 1927.

It might be of interest here to discuss briefly the present position of ferrotitanium and ferrocarbon-titanium in the steel industry as generally accepted by plant metallurgists.

Originally used chiefly in rail steel, where it was found to decrease segregation in the ingot and rail failures in track with marked effectiveness, titanium is now used largely in effervescing or rimming soft steel for sheets. Most plants making steel for high finish automobile sheets have found the use of titanium advantageous for increasing the output of first quality product, improving the rolling qualities and the perfection of surface. Many makers of high grade forgings and of steel plates, some alloy steel makers, and foundries, are also consistent users of titanium. There are wide divergences of opinion, however, among equally well-informed metallurgists, as to its effectiveness.

It is a strange and unexplained fact that it seems to be very effective and well worth its cost in some plants, but of small value in others where the conditions of use are to all appearances identical. Impartial committees have collected and published evidence establishing the value of titanium in rails and in tin plate, but for one reason or another, their findings are not being made use of in practice on a large scale. Aside from the wide acceptance of the value of titanium in sheet steel, its use in the steel industry cannot at present be considered as very strongly established, but is more or less

Etched Section of Heavy A Rail, Rolled From Steel Not Titanium Treated. Reduced about half size

dependent on the personal preference of the individual operator.

If an inexpensive method of producing a pure ferrotitanium, or titanium metal in a reasonably pure form, could be found, many other interesting possibilities in the use of this element in steel or other alloys might develop. One hopeful field of use would be as a scavenger in welding wire, for removing oxide and nitride from fusion welds; and another as a true alloying element in steel, both of which developments require steels with appreciable titanium contents, of the order of 1 to 10%. By melting under controlled atmospheres in induction furnaces, such steels could certainly be made, if the melter had a suitable form of titanium to start with. But to do this cheaply enough to be of practical interest is where the difficulty comes in, and this remains to be worked out.

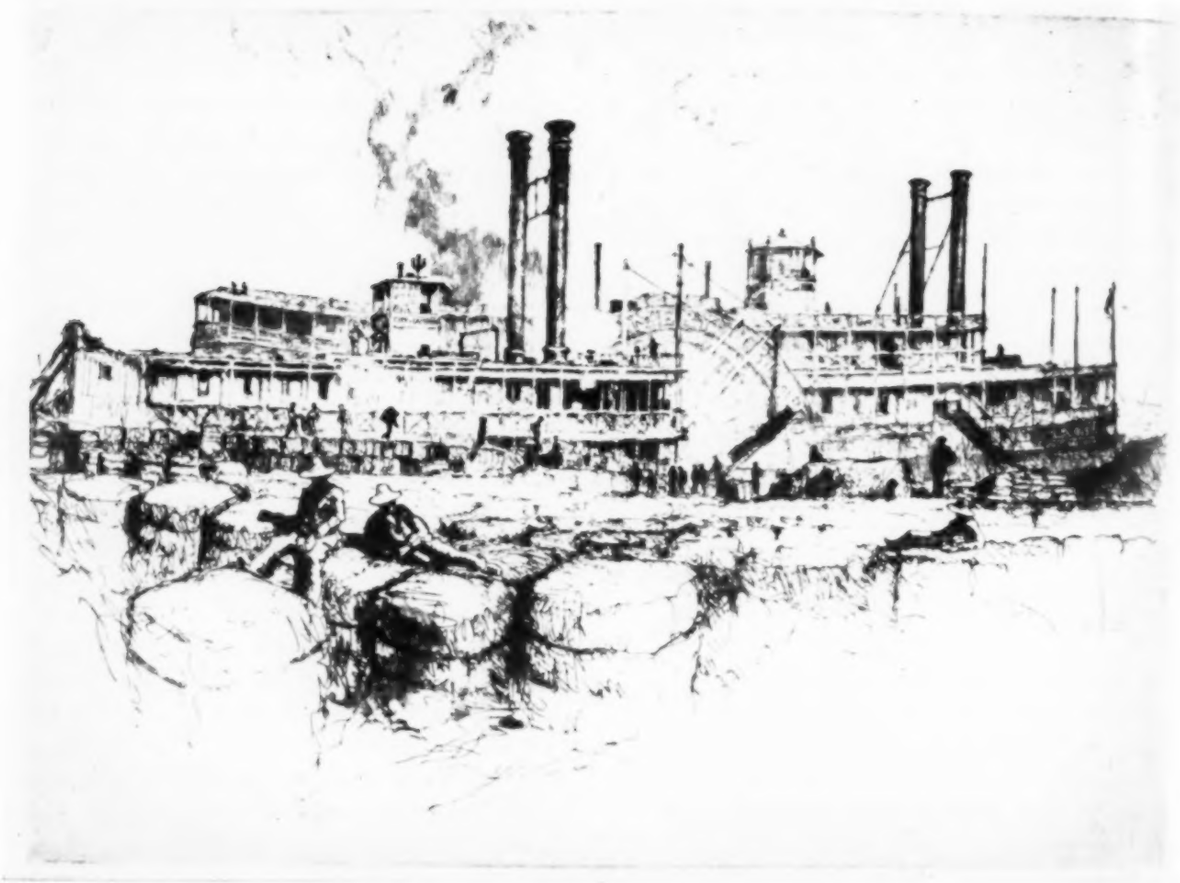
Oxide Makes Excellent Paint

No article on titanium at the present day would be complete without a reference to the very large and increasing use of this element in the form of the pure oxide as a white pigment. This has been discussed fully in a paper by J. E. Heckel on "Titanium Dioxide in the Paint Industry" (*Official Digest* of the Federation of Paint and Varnish Production Clubs, November, 1930.)

Other uses for the oxide, as in arc-light carbons, in ceramics, in connection with dyes for textiles, in quick-setting cement, as a flux in open-hearth practice replacing fluorspar, and for smoke screens in time of war, are either now active in a small way, or have been proposed and show promise of becoming important. But the titanium pigment industry is already the largest outlet for titanium and is growing rapidly.

For pigment purposes all traces of iron are removed chemically to secure the desired whiteness. The superiority of titanic oxide as a pigment is due to its extreme opacity or "hiding power" as compared with other white pigments, so that fewer coats of paint are required to cover up old markings or colors. It is also very stable chemically, and entirely non-poisonous. This development was started by Dr. Rossi in this country and by Dr. Jebsen in Norway at about the same time, but it was not until 1917 that it became commercially important. The pigment is now being made in different forms at several large plants in this country and in Europe, and is shipped in carload lots.

Etched Section of Heavy A Rail, Rolled From Titanium Treated Steel. Reduced about half size



Otto Kuhler's Etching
Shows How 1850
Handled the Traffic

Editorial

Transactions To Resume Publication

TRANSACTIONS of the A. S. S. T. to resume publication as a monthly booklet, next November!

This is the principal thought contained in a statement recently sent to all members by the Board of Directors. It is such an important change in the Society's publication plan that the facts deserve any additional publicity which can be given here.

If one will turn to TRANSACTIONS, April, 1930, page 607, he will find the minutes of the Board meeting which authorized the establishment of METAL PROGRESS, a monthly magazine for "metallurgical subjects, articles and plant write-ups on the following subjects: Forging, non-ferrous materials, manufacture of steel, welding, . . . technical papers presented at conventions."

The plan contemplated that convention papers "and such other papers as the Publication Committee may deem of sufficient importance to be preserved in a permanent record" should be preprinted in pamphlet form, free to all members on application, later to be collated with discussion and republished in bound volumes which would be sold to members at bare cost.

These projects have been carried out. TRANSACTIONS ceased monthly publication in September, 1930, and within three months after the Chicago convention Volume 18 of TRANSACTIONS was ready. It contained all the papers and discussions of the convention — a notable array. Practically all of the text (except discussion) had already been distributed to members free of charge, either in the July or August issue of the monthly publication, or in the form of preprinted pamphlets. Nevertheless the entire material was again rearranged, placed on the presses, and issued in a bound volume for those who desired to pay for the binding.

As pointed out by the recent letter from the Board of Directors, this resulted in a loss of $5,000, in spite of the fact that as many as 1,600 members have already ordered the volume at $2.50. This loss was expected, but the expense of adding this store of information to the permanent literature of the metal industry is a justifiable charge against the treasury of the A. S. S. T. The Board was also gratified at the unexpectedly large number of members who are preserving the TRANSACTIONS in their working libraries.

METAL PROGRESS is now in its eighth month, a lusty infant. It has been highly praised by numberless members of the society and is setting the pace for the entire trade and technical press. For these reasons it has received a substantial volume of advertising (at a rate double that of TRANSACTIONS) notwithstanding the hard times which has cut into nearly every advertising appropriation, and which is responsible for a sharp recession in advertising space carried even by the oldest and best established journals. These facts justify the Board's belief that the publications of the society have an earning power which is more secure and permanent than exhibitions or any source of revenue other than membership dues.

Having effected some economies during the low spot of the business depression by avoiding monthly publication of TRANSACTIONS, and facing an unprecedented offering of papers for the next convention in Boston, the Board of Directors now votes to resume publication on November 15 in the familiar form (a 6 x 9 pamphlet, suitable for binding) and at no expense to the members. This date is as soon as contributions

• Editorial

and discussions can be assembled from the Boston convention.

It is the more glad to make this announcement promptly, in order to quiet the fears of some valued members, who have missed the receipt of a monthly publication devoted exclusively to the more scientific and technical aspects of the society's field, even though there has been, nor would have been, no loss in the amount or number of this type of contributions harbored in TRANSACTIONS under either publication plan.

Now, in addition to the local meetings and social contacts offered by any American technical society, the far-flung activities of the American Society for Steel Treating include joint chapter and regional meetings, annual conventions, expositions and congresses in both East and West, an authoritative handbook, and the three monthly publications, METAL PROGRESS, TRANSACTIONS and REVIEW. Surely, within this unexampled program, every progressive and forward thinking man in the metal industry can find ample warrant for a membership, and also the privileges of membership will convince him that it is the best buy he makes!

Information For Him Who Can Use It

NO MATTER whether methods of X-ray investigation are entirely understandable to the ordinary men working with metal or not, it would appear that in a few years it has become a favorite tool of the laboratorian and researcher. One day's sessions at the recent meeting of the Institute of Metals Division (A.I.M.M.E.) contained, for instance, no less than five addresses wherein the speaker's remarks depended upon evidence collected by this means. Fortunately, as Dr. Jeffries pointed out, it is not necessary for all of us to be expert X-ray technicians, nor microscopists, nor physical chemists, before we can profit by the studies of those who are.

The most "practical" applications (that is, the X-ray work which has to do largely with inspection of completed articles) are done very simply — so simply, indeed, that the method is utilized by thousands of dentists and physicians. It is called radiography, and consists merely of shooting rays through the object and stopping them by a photographic plate or film. This gives a shadow picture of the object, recording any hidden holes or sizeable defects. It is a non-destructive method of testing, and a variety of photography requiring only some specialized equipment. It has proven to be worth its cost in inspecting important parts and assemblies and in developing proper manufacturing technique, especially in foundries.

A much more abstruse study of the inner structure of metal is possible by photographing the reflected or diffused X-rays, rather than making a direct shadowgraph, as mentioned above. Since the essential structure of metal is crystalline, the atoms are regularly arranged in rows and ranks, and this regularity in position causes regular reflections of the impinging rays. There is a definite relationship between the spots and circles registered by the reflected rays on the photographic plate (called an X-ray spectrogram from its essential similarity to the spectrum of light) and the spacing of the atoms. An ingenious person (a combination geometer, crystallographer, and puzzle solver) is able to measure the distances between atoms, determine whether solid solutions or chemical compounds exist, and sometimes even locate the position in the space lattice of the various elements which comprise the compound. Correct information on such subjects is, of course, of highest interest to theoretical metallurgy and metallography — and it is a truism that the theory of today is the practice of tomorrow.

Valuable applications of the X-ray spectrogram have also been made which do not require a geometric analysis, but rather use a qualitative estimation of the sharpness of the images. It has been found that the "focus" or clarity of such spectrograms depends upon the average crystal size and also upon the amount of cold work which has been done. Inferentially, this is related to the internal strain within the metal.

Editorial

Studies of this sort have been able to guide the manufacture of sheet metal and wire for special purposes where uniformity of properties in all directions is a requisite.

These brief remarks support the original premise: That whereas special equipment and a special operator are required for best results in X-ray metallography (the same as are required for portrait or any other class of photography), it requires nothing but ordinary intelligence and a mind receptive to new ideas to apply the information gained to the task of making metal better, and better parts thereof.

Die Casting Developments Just Ahead

COOPERATION has again proven its worth to the die casting industry. Only a few years ago all such work was done behind fences; trade secrets and new developments were jealously guarded. Today its technical men are meeting regularly for the acquisition and pooling of information, a trade association has been formed by the managers, and more than one important plant has gone so far as to open its operations for inspection.

No small part of this improved situation is due to the activities of a committee of the American Society for Testing Materials. Its moving spirits came from a few producers and consumers who were anxious to develop specifications which would insure delivery of castings usable as engineered products, and not merely "space fillers". As is so often the case, it was immediately apparent that insufficient accurate information about the properties of the article to be specified was available, and the first thing to do was to make a large number of test bars in various alloys and to study them.

Progress in the understanding of die casting problems has been rapid since that time. Perhaps outsiders have acquired a false impression about the importance of recent developments, since so little information was given out in previous years, during which the industry was undoubtedly moving forward. Nevertheless, the studies of the A. S. T. M. committee will establish authoritative data on about two dozen alloys, as to the permanence of dimension, strength or corrosion resistance. They have already clarified questions regarding the stability of zinc-base alloys, and will do much toward removing the odium thrown on the industry by the poor performance of alloys made before the deleterious effect of certain minor elements was understood.

New Jersey Zinc Co., and Aluminum Co. of America have been especially active in investigating this subject. Incidentally their laboratories have produced metal of almost spectroscopic purity, in order to get the ultimate answer to this and other problems concerning the commercial use of the two metals. As one result, three new zinc-base alloys have recently been announced by the first mentioned company which appear to have unusually desirable properties. One of them utilizes metals of highest purity; in no other way, apparently, can the desired results be obtained.

Other developments also seem to be just around the corner. Rumors are heard and samples are exhibited of hard, strong, brass-like castings. Almost everyone knows that the die casting art, as practiced today, is limited by the ability of the pots and the dies to resist dissolution and corrosion. The higher the temperatures at which the alloys melt and cast, the greater the difficulties, until they become insuperable, and die casting of brass and bronze (as we know these alloys, having ultimate strengths approaching 60,000 lb. per sq.in.) has so far been a hope rather than an accomplishment. Nevertheless, one may believe that one or more things are within the realm of possibility: Stronger alloys which melt at low temperatures; corrosion resisting steels for dies and containers, able to operate at higher temperatures; revolutionary changes in operating technique or mechanical equipment, which remove the present limitations of the machine.

Any of these developments would open a wide new field for the die casting industry, and extend its usefulness immeasureably.

How To Plate Aluminum Die Castings

By HAROLD K. WORK
Aluminum Research Labs.
Buffalo, N. Y.

. . . THERE is a widely prevalent belief that aluminum die castings cannot be plated. Actually this is not true. As a matter of fact, aluminum die castings present special advantages as a base for plating. Furthermore, the plating operation is readily accomplished.

Commercial electroplates have been made on the surface of the die casting, as smooth polished or after special roughening: Zinc and chromium have been plated on the usual smooth polished surface of the aluminum. Zinc, thus applied to die castings, has not yet found any commercial application, and the direct plating of chromium on the aluminum has had a relatively limited usefulness. Up to the present its main advantage has been to increase the alkali resistance of such articles as washing machine agitators, and to improve the abrasion resistance of ironer shoes.

More extensive fields for use of the plated die castings can be obtained by roughening the surface before plating to secure an anchorage of the plate. Simply to produce an irregular surface, such as might be obtained by sand blasting, is not sufficient. A roughened surface in which the irregularities and pits have a special undercut shape must be produced so that the coating, electrodeposited in these undercut openings, will be satisfactorily attached to the surface. Such a surface is attained by a special reagent, described by the writer before the American Electrochemical Society, and printed in its *Transactions* for 1928, vol. 53, p. 361.

This reagent dissolves out certain portions of the surface selectively, and the number, character, and placing of these openings is somewhat affected by the composition of the alloy which is being etched. Some of the typical compositions of die casting alloys are listed in the table.

Alloy Designation	Copper	Silicon	Nickel
13	...	12.0	...
83	2.0	3.0	...
85	4.0	5.0	...
93	4.0	2.0	4.0

Surface roughening can be very easily accomplished, due to the structure of the die cast metal — the alloying materials are scattered through the alloy in a network structure. It is by selectively dissolving out these alloying materials that the pits which serve as anchorage for the plating are formed.

The etching dip consists of three parts of concentrated nitric acid (specific gravity 1.42) to one part of 50% hydrofluoric acid. It rapidly dissolves the alloying additions, but attacks the aluminum at a relatively slow rate. For this reason, formation of the anchoring pits can be accomplished by a short dip, say 10 to 30 sec. The micrographs show how these anchoring pits are shaped to conform to the structure of the die castings, and run down into the metal where the alloying constituent has been removed.

To prepare the aluminum for the above etching, it is merely necessary to dip the metal for about 30 sec. in a hot alkaline cleaner composed of one ounce per gallon each of sodium

carbonate and tri-sodium phosphate. Such a cleaning solution attacks the metal slightly, causing a gassing at the aluminum surface, which assists in the cleaning by mechanically scouring the surface. Its action is similar to electrolytic cleaning.

In plating over the specially roughened surface described above, it has been found advisable to use nickel as the preliminary coating. The physical properties of the nickel plate make it peculiarly suitable in forming these anchors for holding down the plate. Anchors of softer metals will tear out of the pits on stress. Once a satisfactory nickel plate has been applied, it is easy to coat with any of the usual metal plates.

The nickel plating solution is somewhat similar to that used for zinc die castings. It is advisable to add either sodium sulphate or magnesium sulphate to the bath to increase polarization. While many nickel baths may be satisfactorily used for aluminum, two have been most generally selected. The first contains

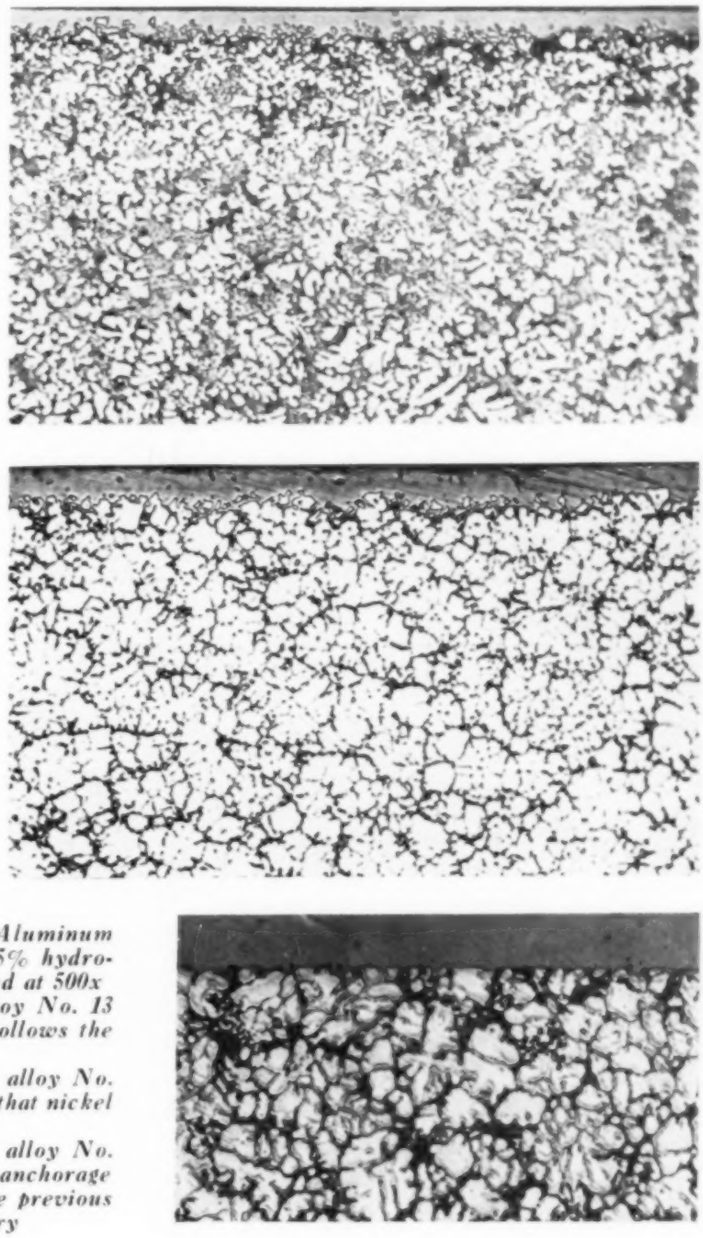
	Ounces per Gallon
Nickel sulphate ($NiSO_4.7H_2O$)	19
Magnesium sulphate	10
Ammonium chloride (NH_4Cl)	2
Boric acid (H_3BO_3)	2
Temperature	90 to 95° F.

A second plating bath, according to the recommendations of M. R. Thompson, *Transactions*, American Electrochemical Society, vol. 47, p. 163, contains anhydrous sodium sulphate.

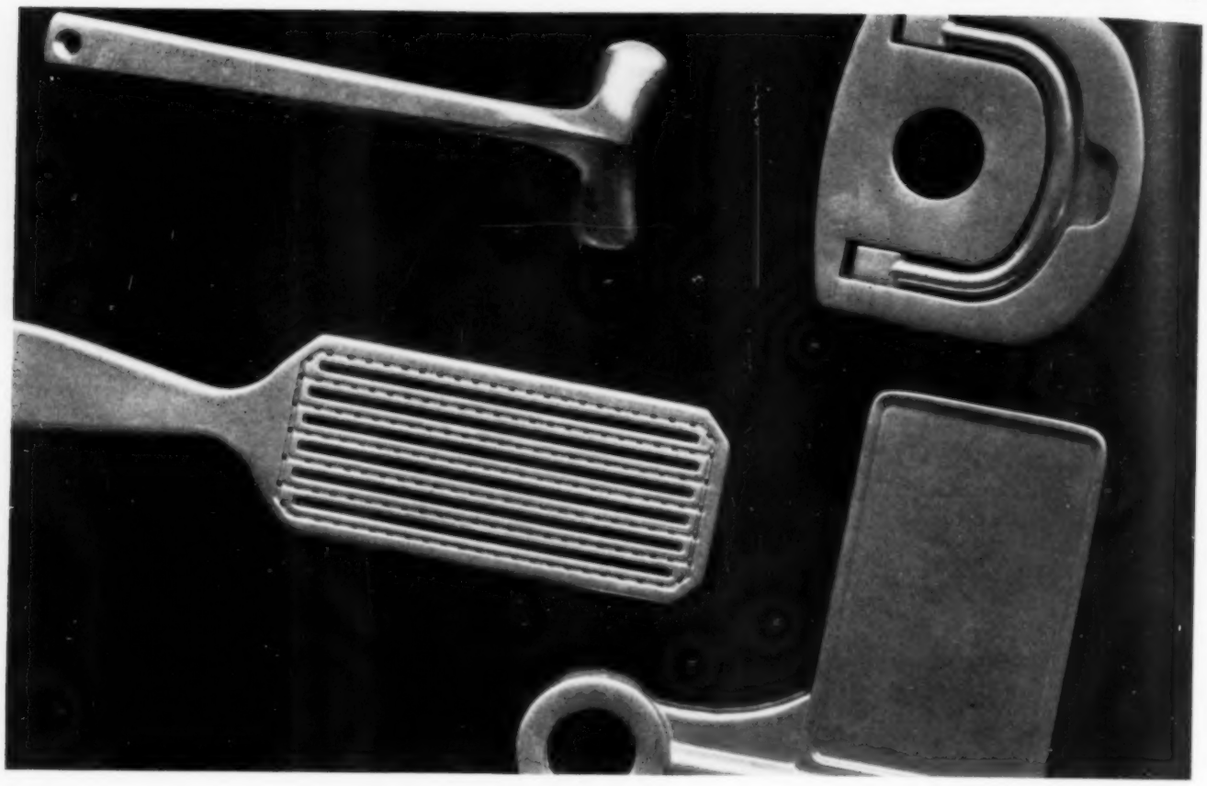
Nickel sulphate ($NiSO_4.7H_2O$)	16 oz. per gal.
Anhydrous sodium sulphate (Na_2SO_4)	26 oz. per gal.
Ammonium chloride (NH_4Cl)	2 oz. per gal.
Boric acid (H_3BO_3)	2 oz. per gal.
Temperature	90 to 95° F.

A current density of 15 amperes per sq.ft. is advised for both solutions, although under special conditions changes are advisable. A pH value of 5.8 to 6.0 (colorimetric) gives good results. Generally the lower the pH the better the solution will throw into the recesses.

With the commonly used die casting metals, zinc and aluminum, the nature of the cor-



Micrographs of Nickel Deposits on Aluminum Base Die Castings. All etched with 0.5% hydrofluoric acid for 15 sec. and photographed at 500x
Top View: Deposit on die casting alloy No. 13 (12% silicon). Note that nickel plate follows the network structure
Middle View: Deposit on die casting alloy No. 83 (2% copper, 3% silicon). Note again that nickel plate follows the network
Lower View: Deposit on die casting alloy No. 85 (4% copper, 5% silicon). While the anchorage is not as good with this alloy as with the previous two, it is nevertheless satisfactory



rosion of the plated die castings is basically similar. The die castings themselves corrode in preference to the coating metal, and consequently the plate tends to pit at pin holes in the plating. It is difficult to employ a heavy coating on zinc die castings, since once the corrosion gets through the heavy coating the plate may blister or peel and expose relatively large areas of the base metal.

Characteristics of Plated Castings

If the procedure outlined is used with aluminum die castings, this difficulty does not exist; the application, therefore, of heavier plates which normally contain fewer pores than a thin plate is allowable. As it is generally recognized that heavier plates will be much more resistant to corrosion, barring the peeling and blistering such as is encountered with plates on zinc die castings, it is obvious that aluminum die castings can be plated so that they will have considerably better corrosion resistance than can be obtained with plated zinc die castings.

By applying a fairly heavy plate, say 0.001 in., castings have been exposed in the salt spray test cabinet for more than 200 hr. before any sign of pitting was noted. This particular advantage of plated aluminum die castings makes them suitable for applications where high corrosion resistance is needed, in combination with die casting as a method of fabrication.

Several Uses Already Found

While the procedure described is relatively new, it has, nevertheless, already found several uses. Beauty appliances, parts of electric clocks, taximeter flags, ash trays, musical instrument parts, and automobile hardware have all been manufactured as plated aluminum die castings. A few of these are illustrated. The advantage in plating these various articles is to make the die casting match in color other associated parts and to enhance the appearance of the objects. Another application where plating of die castings bids fair to become important is in the plating of ironer shoes; chromium directly on the aluminum is effectively used here for abrasion resistance.

Cast Iron Pipe Competing With Steel

• • • ONCE a great mail order house decided to build tractors in Springfield, Ill., so it built a modern plant. Then it suddenly decided not to build tractors, so the fine new plant stood vacant.

Some years later, American Radiator Co. chose it as the place to start commercial production of a new kind of cast iron pipe developed after a lengthy investigation at its Ypsilanti, Mich., plant. First production at the last-mentioned place occurred in May, 1926.

These preliminary investigations into the methods of producing a special cast iron pipe had given much promise when, in the spring of 1927, the American Radiator Co. bought the Springfield property. However, there were still some troubles in the manufacturing process which had to be ironed out, and the first year at the new plant was spent almost entirely in research and experimental work. It was not until 1928 that production of Arco metal pipe, as it is called, started in earnest.

The thought behind this development was that it should be possible to make a thin-walled pipe of high strength cast iron which would at one and the same time have the well-known corrosion resistance of cast iron pipe, the ability to be coupled with screwed fittings (standard joints for steel pipe), and the ability to be welded by modern oxy-acetylene practice.

Bell and spigot pipe is too thick in the wall, consequently wasteful in freight and handling charges. Furthermore, it is difficult, if not impossible, to make a satisfactory joint by caulking and lead seal which will remain permanently tight and leak-proof against even slight pressures. Thin-walled pipe with screwed or welded connections avoids these difficulties with a much less expensive joint to make.

By the method of manufacture finally chosen by American Radiator Co. — namely, casting superheated low-alloy cast iron in hot baked molds, set vertically — the engineers responsible for this development believe they have a pipe which can be threaded cleanly from end to end, and which will carry normal working pressures even though the wall thickness is no greater than extra strong steel pipe. Outside diameters are the same as those of steel pipe of the same nominal dimensions, so standard fittings and standard thread-cutting dies can be used.

Today the Springfield plant is able to cast, in vertical molds, 8,000 to 10,000 ft. of pipe per day in sizes from 1½ in. to 6 in. nominal outside diameter.

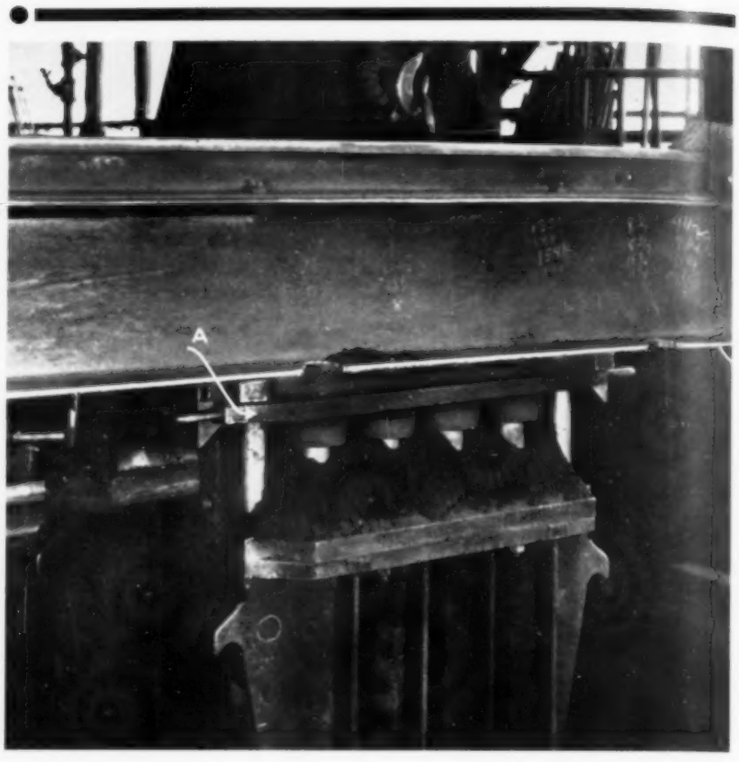
Casting in vertical molds was finally chosen as the correct method of manufacture because it seemed the best way to produce a perfectly round tube with no parting seams along the sides, no swells or gates in the full length of the pipe, and no difficulties from

Top of Pipe, as Cast, and Before Cleaning. Gates and risers are formed by cores set in belled top of mold

chaplets. Uniform wall thickness was also possible no matter what size of pipe is being made.

During the period of development and research, Arco metal pipe was cast horizontally by the cope and drag method and also in a centrifugal casting machine. Both methods were discarded, however, in favor of the method illustrated in these pages.

Production at Springfield is obtained from two pipe producing units designed and laid out by the company's engineers to achieve the economies possible in straight-line production. These units, complete with equipment for making and baking sand cores and molds, for pouring, cooling, and shaking out, are each only 150 by 40 ft.



At the front end of each production unit the molds and cores are rammed. Overhead hoppers deliver a supply of a synthetic sand of high permeability. Sand for the molds flows directly into the long cast iron flasks and is rammed into place around the pattern by a compressed air jolter. This operation is shown in the view on page 72. On a little spur of the production line at the same end of the unit the cores are built on arbors to assure straightness (page 73).

Molds and cores are then carried ahead by a crane to conveyors which move slowly through a gas-fired oven, an integral part of each unit. Cores are baked for 2½ hr. and the molds for an hour. The oven of the unit used for the four largest sizes of pipe (3 in., 4 in., 5 in., and 6 in.) is 70 ft. long; the other is 10 ft. shorter. When they leave the oven, the hot cores are set in the molds and fitted with centering cores at the bell-shaped mold-top. Size and shape of these cores can be inferred from the view on page 71 of the top end of a pipe, as cast.

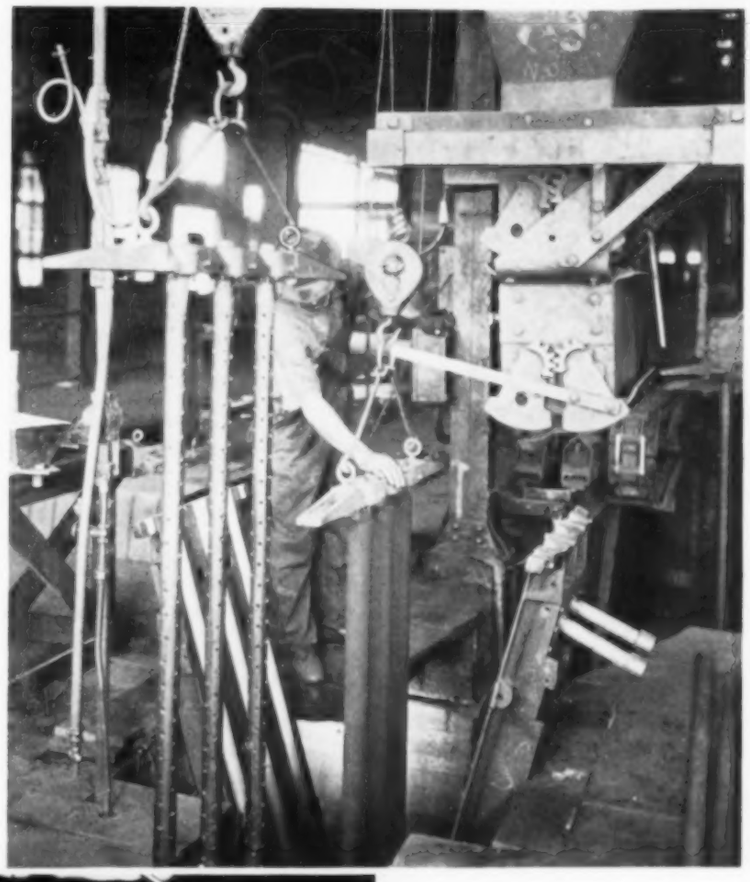
Flasks used for the four largest sizes are three-chambered, while the smaller ones, used for the 1½-in., 2-in., and 2½-in. sizes, contain four molds. Pouring of superheated iron is done by hand from 500-lb. ladles as soon as possible after baking the molds, so that chilling can be eliminated, the amount of combined carbon kept to a minimum and the segregation of elements be prevented. Cooling is in the molds, following which is the shake-out, the last operation in the unit.

With the exception of the cranes, all power used in the pipe producing units is compressed air, supplied at a pressure of 90 lb. per sq.in. Jolting machines, hoists, conveyors, and shake-out are all operated by air, the cheapest and most efficient power for such work, according to the plant's officials. An extra compressor is on hand for emergency use.

Pipes are cast into 6-ft. lengths. After being shaken out they are taken on skids by electric lift trucks to a cleaning room where the gates are cut off. The pipe is then tumbled, and the ends ground true. Next, the pipe is 100% inspected. All pipe lengths are tested hydrostatically at a pressure of 300 lb. per sq.in. (At a customer's request, the test pressure is raised as high as 1,000 lb.)

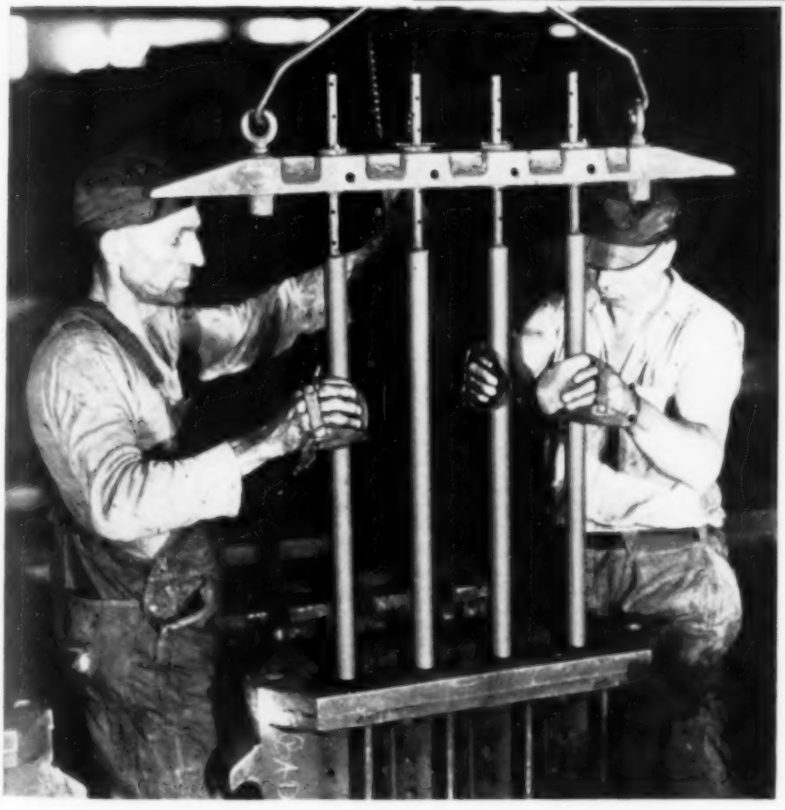
Threading is done by machines in the plant, although in the field the threads can be cut

Top View of Quadruple Flask While Mold Is Being Rammed. Patterns for four pipes are rigidly held on correct centers. Plate A, to form pouring basins, is held in raised position until mold is filled with sand



Making Cores for a Triple Mold. Ventilated arbors hung from spacing bar are shown in foreground. Operator has rammed up a set, the core box has been opened, and he is about to transfer the green cores to the oven

Baked Cores Are Placed Into Dried Molds While Both Are Hot. Note how jig is made to center cores accurately



easily by hand. Pipe is painted a distinctive red color, and marked with the trade name to prevent its becoming mixed with steel pipe in a warehouse stock. It is shipped with thread protectors on each end.

A large department is maintained for welding the pipe into lengths longer than 6 ft. An alloy cast iron welding rod is used of such composition that the joint in the pipe will be almost identical in composition and properties to the wall. Numerous tests show that the weld — a V-butt joint made by the oxy-acety-

lene process — is as strong as the original pipe. Welded pipe lengths are tested hydrostatically a second time after welding.

While the pipe is close-grained and strong, it is readily machined. The analysis calls for chromium 0.2%; nickel 0.1%; silicon 2.50%; manganese 0.75%; phophorus 0.4%; sulphur less than 0.1%; and total carbon 3.40, of which 0.50% is combined and 2.90 is graphitic. Hot metal is superheated in the cupola.

Numerous tests made under laboratory conditions and a large quantity of pipe in service show that this high strength cast iron pipe has excellent resistance to soil corrosion (even in such severe locations as in cinder ballast) and to acid or alkaline liquors and trade wastes. It is, of course, not claimed to be non-corrosive, in the sense that Duriron or tile pipe is non-corrosive, but undoubtedly is more resistant than plain steel or wrought iron, and apparently somewhat more resistant than common cast iron pipe. Numerous laboratory and service tests have been made along this line.

The physical properties of the metal reflect to a considerable extent the fine grain structure produced throughout the metal by the method of melting and casting, and the presence of a small amount of the alloying elements, nickel and chromium. Fractures of test bars one inch square show the grain at the center of the bar to be fully as fine as that at the skin. The tensile strength is 28,000 to 32,000 lb. per sq.in. and the elongation is approximately 0.5% in 2 in.

A deflection of 0.24 to 0.26 in. is measured from the standard bending test, in which a 1-in. square bar is supported on 12-in. centers and loaded in the center. The flexural load at fracture figures to 3,000 to 3,300 lb. per sq.in. Brinell hardness of the pipe tests in the range from 190 to 210.

Tension tests on screwed pipe-runs ordinarily break the pipe wall before the thread parts. Average results of such tests give 12,500 lb. for 1½-in. pipe, and approximately 100,000 lb. for 6-in. pipe. Compressive strengths in short lengths are about the same.

Bursting pressures are in the neighborhood of 4,000 lb. per sq.in. for 1½ and 2-in. pipe, 2,400 lb. per sq.in. for 3 to 5-in. pipe, and 1,500 lb. per sq.in. for 6-in. pipe.

Arco metal pipe is finding its widest market in the plumbing and oil industries, where durability, machinability, and some resistance to corrosion are desired. Metal of the same composition used in the pipe is also cast into refrigerating units, couplings, fittings, and other pipe accessories.

Pipe Is Cast One by One. A double row of molds move slowly on a conveyor past the casting platform

A Carburizing Plant Under Scientific Control

By R. G. GUTHRIE
AND J. A. COMSTOCK
Consulting Metallurgists

. . . IT WAS ONLY a few short years ago that the treatment of steel was more of an art than a science. Special steels had not come into general use and very little of a scientific nature was known regarding ordinary carbon steel. The man at the fire, who had the responsibility of hardening or softening the material as required, was of necessity something of an artisan. He had no scientific apparatus to guide him — such as pyrometers, heat controllers or microscopes — but depended entirely upon his observation of certain phenomena within his personal experience. His knowledge of the craft was obtained by word of mouth and example, and very frequently it was the son who carried on the father's work.

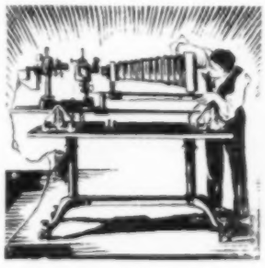
Consequently, the steel treater was highly secretive about his bag of tricks, and, more than anybody else, resented the encroachment of laboratory science. What few laboratories there were in those days were conducted more or less as experimental departments, being entirely detached from the problems of production.

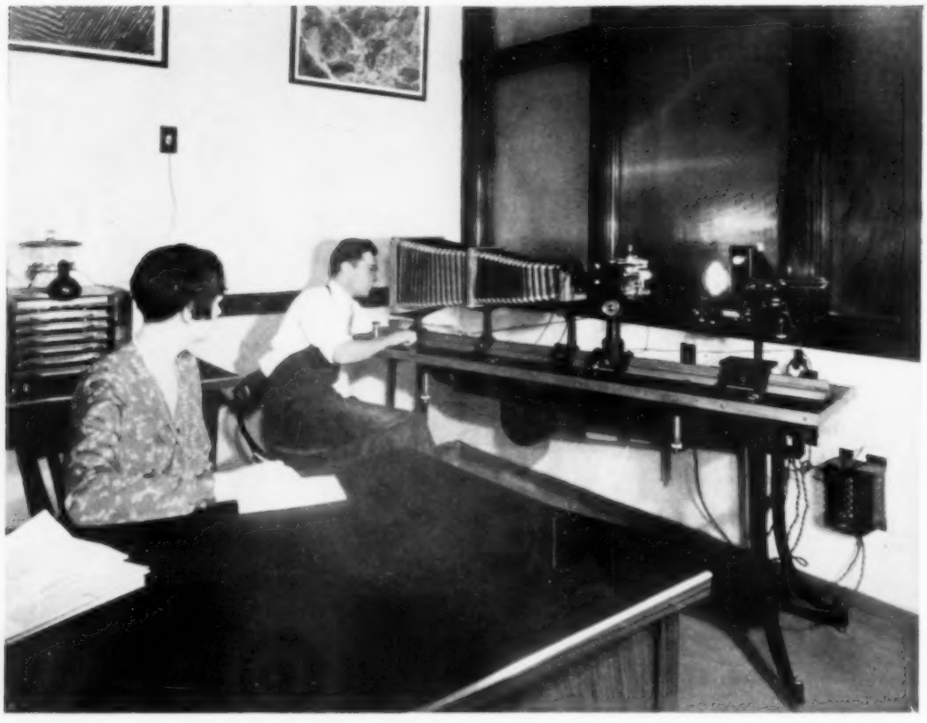
The advent of automatic machines, mass production, alloy steels, stainless irons and steels, and special tool materials has transformed the manufacturing of iron and steel products from an art to a science. Rule of thumb methods have given way to procedure control, based on scientific facts. Today the laboratory is a necessity. As an instrument of control it very often spells the difference between success and failure, and, in every instance, leaves a definite impression on the efficiency of the plant and the quality of its manufactured product.

A Metallurgical Control Laboratory for a plant manufacturing metal products should afford certain facilities that are more or less standard today.

Undoubtedly the most important tool of the metallurgist is the metallurgical microscope. The microscope is the only instrument now known to science for studying the physical makeup of materials or, as the metallurgist would call it, the proximate analysis. For preparing metal specimens for microscopic analysis, the laboratory must be equipped with sample preparation apparatus, consisting of a grinding machine, polishing machine, and facilities for etching.

Hardness testers of one or more types are indispensable to such a laboratory, as are also small furnaces used for heat treating specimens to determine the physical properties of metals in the heat treated condition. Apparatus and supplies are needed for chemical analysis. Arrangements must also be made for obtaining the necessary fuel and power as well as compressed and low pressure air. Last, but not least, no laboratory is efficient that does





Microscopic Examination of Metal Received or at Various Stages in Process Gives Much Valuable Information for Control of Manufacturing Operations

not afford something of a library for daily reference use.

One of the most important duties of the control laboratory is to *inspect the raw material* which is to be used either in the manufacture of the product or in making tools. In this way, alone, the laboratory can be made to more than pay for itself, by eliminating the expense of manufacturing parts which later have to be rejected for reasons which could have been detected by inspecting the raw material. Inspection procedure will depend a great deal upon the use to which the metal is to be put.

For example, steel that is to be used for carburizing purposes should be thoroughly checked for its carburizing characteristics before spending any money machining parts prior to carburizing. The very fact that not all steels will carburize alike, but possess widely different structures in the carburized case, is sufficient reason for examining specimens of every heat of steel to be used for this operation. Furthermore, the subsequent heat treating operations necessary to harden the carburized parts will depend a great deal on the type of carburized case. It is well known that certain steels carburize slower than others, both in regard to carbon penetration and carbon concentration, and this specific information cannot be detected merely from a chemical analysis of the steel. About the only positive method of inspection is to go to the trouble of actually carburizing specimens from each lot, and then make a microscopic examination of these specimens before and after the hardening treatment.

Material that is to be used for machining stock, as well as that which is subjected to forming and shaping, should be first tested for hardness and then examined under the microscope to determine its proximate analysis. For these operations it is highly important to know whether the carbide constituent is lamellar, sorbitic, or spheroidized.

Some products require very clean material — that is, material free from inclusions of nonmetallics, commonly called dirt — and, here again, the microscope is indespensable. Also, it is possible, by etching tests, to detect surface defects such as seams, cold shuts, subcutaneous blow-holes and pipes. All of these features will influence, to a definite extent, the quality and service life of the product. Segregation of carbides, dendritic formations, and banding are easily found by both macroscopic and micro-

scopic examination, and these common causes of failure can be eliminated by inspecting the raw material before any manufacturing expenses occur.

Steels that have to be hardened to obtain definite physical properties should be inspected for hardenability. This may be done by simply examining a specimen that has been hardened in the laboratory and determining the degree of hardness, uniformity of hardness over the surface, and the depth of hardness for the given heat treatment.

It is not always possible to predict the hardenability of a steel merely by microscopic analysis of the steel as delivered, since this quality is often inherent in the iron content and results from the treatment it has received in manufacture. However, the microscope is used to determine the type of microstructure the steel has, as delivered, an important point to know when it comes to hardening the parts, especially if they do not receive any normalizing treatment at the plant. For instance, an 0.85 carbon steel may ordinarily be received either in sorbitic or spheroidized condition. If the material is sorbitic, it will require a much shorter soaking time and for all practical purposes a lower hardening temperature will suffice. However, if the material is spheroidized, it is practical to go to higher temperatures and it may be necessary even to soak the piece longer to obtain the desired efficiency in the finished tool.

Where a great deal of such material has to be inspected before being put into production, it is entirely feasible to do away with the microscopic inspection, once the laboratory has determined the corresponding hardness numbers for the different microstructures.

For example, an 0.85 carbon steel in the spheroidized condition will have a hardness of less than 90 Rockwell B scale, whereas an 0.85 carbon steel in the sorbitic condition will have a hardness greater than 90 Rockwell B scale. Testing for hardness will therefore give a very thorough inspection to all material of this type, without going to the time and expense of preparing micro-samples.

Another point: Many parts do not have any machining or grinding performed on them in the entire process of manufacture, and if it is necessary to obtain a very hard surface by heat treating such parts, it is absolutely essential to inspect the raw material for surface decarburization. This condition is common, in some degree or other, to all steel purchased in the annealed condition and it can be very easily determined just what the operating limits of the surface decarburization will be for any given job.

As the result of the information obtainable

from a thorough inspection of materials, the laboratory is in a very good position to draw up comprehensive and workable *specifications for materials* to be used for all purposes throughout the plant. Such specifications, in a great many instances, may contain in addition to chemical analysis such items as microstructure, hardness, segregations, inclusions, normality of carburizing stock, hardenability of tool steels and bend tests.

Process control is purely the realm of the laboratory. The metallurgist not only should specify details of the process but should also control the various operations. He should be consulted in the purchase of all types of equipment, such as machines for forming, stamping, machining, and grinding; furnaces for normalizing, annealing, hardening, tempering or carburizing; as well as accessories, such as pyrometer equipment, type of fuel to be used, heat treating supplies, and inspection tools.

As an example of the extent to which the laboratory can be utilized to specify the various manufacturing processes as well as the equipment necessary to obtain the desired results, the authors cite the following, having specifically to do with the heat treating of special parts. The metallurgist recommended the manufacture of these parts out of easy machining stock, to be subsequently carburized and heat treated to obtain wear-resistant surfaces. The proposed plan and flow sheet for such a heat treating department shown on this page, is based on the latest developments in processing and furnace design.

Due to the delicate nature of the parts, carburizing is done in stationary, vertical retort furnaces, utilizing the gas carburizing process. By means of heat exchangers, the cold work to be carburized is preheated and the hot, carburized work is uniformly cooled.

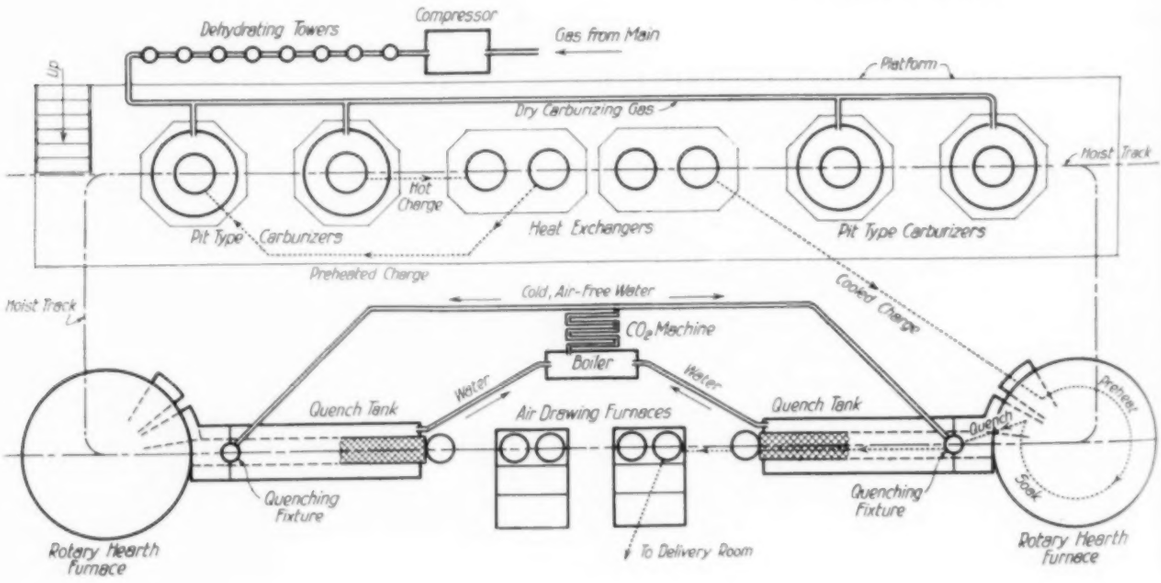
Rotary hearth furnaces controlled by automatically repeating process timers, reheat and deliver the parts for individual quenching in a special quenching fixture into boiler water kept cool by a CO_2 machine.

A mesh conveyor lifts the work out of the quench and loads it into baskets for tempering in recirculating air furnaces.

The equipment is arranged to allow straight line operation. A continuous monorail and electric hoist system does away with all hand labor in connection with removing furnace parts and covers, charging and discharging work, and transferring the work throughout the entire process from the receiving room to the delivery room.

Recording automatic temperature control apparatus finishes the lay-out, makes it capable of the highest type of scientific control, and assures perfect duplication of the finished, heat treated product.

Schematic Lay Out and Flow Sheet of Modern Carburizing and Heat Treating Department Capable of Close Control in Mass Production



Well Equipped Dark Room Is Essential for Satisfactory Photo-Micrographic Work

Following is a list of the equipment required for the layout shown:

3 Vertical retort carburizing machines
2 Heat exchangers
2 Quenching tanks with conveyors
2 Rotary hearth furnaces
2 Recirculating air drawing furnaces
10 Sets of loading fixtures for carburizing machines
1 Sheet metal shroud
1 Gas compressor
8 Gas dehydrating towers
3 Sight feed lubricators
1 One-ton electric hoist and complete monorail system
1 Rapid oil cooler and stand with motor driven pump
16 Valves (automatic)
8 Indicating potentiometer controllers
8 Recording controllers with re-roll attachments
Thermocouples
Protection tubes
Lead wire

Carburizing with city gas requires compressing the carburizing gas to from 12 to 15 lb. per sq.in. Each furnace will require approximately 150 cu.ft. of carburizing gas per hr. Compressed gas must be dehydrated by passing it through calcium chloride towers.

Near the points where the dry, compressed carburized gas enters the individual carburizing furnaces, a definite amount of water is added to the incoming gas stream by means of sight feed lubricators.

The carburizing gas thus prepared is admitted at the bottom of the various retorts and passes upward throughout the charge of work, leaving the retort through a vent control by a valve to regulate the exact amount of gas flow. On coming into contact with the air it burns, on being ignited, in a typical flame, the characteristics of which depend on the pre-treatment of the gas and the rate of flow.

By means of a special fixture built of heat-resistant baskets on a central stem, various parts to be carburized can be heated with proper spacing to insure uniform flow of carburizing gas around them. The loaded fixture is arranged for charging and discharging in and out of the retorts by means of an electric hoist and monorail system. While being transferred to the heat exchangers, the hot work is protected from the air by means of a Universal metal shroud.

Allowing an average total time of six hours per charge for charging, heating up, carburizing, and discharging the various parts, the three furnaces would turn out approximately 12 charges per 24 hr.

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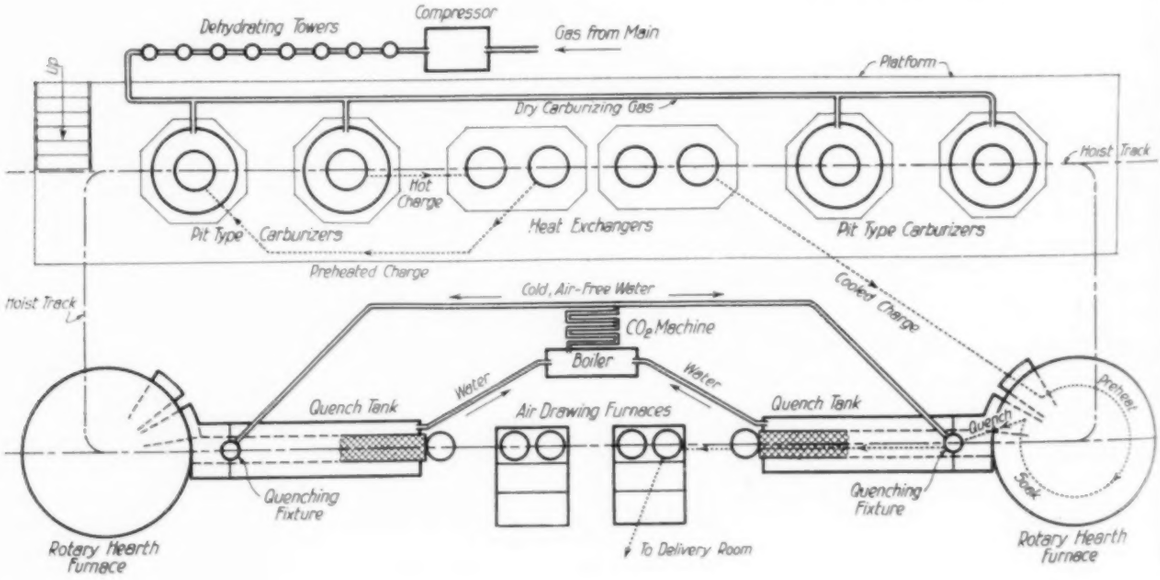

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3 Sight feed lubricators
1 One-ton electric hoist and complete monorail system
1 Rapid oil cooler and stand with motor driven pump
16 Valves (automatic)
8 Indicating potentiometer controllers
8 Recording controllers with re-roll attachments
Thermocouples
Protection tubes
Lead wire

Carburizing with city gas requires compressing the carburizing gas to from 12 to 15 lb. per sq.in. Each furnace will require approximately 150 cu.ft. of carburizing gas per hr. Compressed gas must be dehydrated by passing it through calcium chloride towers.

Near the points where the dry, compressed carburized gas enters the individual carburizing furnaces, a definite amount of water is added to the incoming gas stream by means of sight feed lubricators.

The carburizing gas thus prepared is admitted at the bottom of the various retorts and passes upward throughout the charge of work, leaving the retort through a vent control by a valve to regulate the exact amount of gas flow. On coming into contact with the air it burns, on being ignited, in a typical flame, the characteristics of which depend on the pre-treatment of the gas and the rate of flow.

By means of a special fixture built of heat-resistant baskets on a central stem, various parts to be carburized can be heated with proper spacing to insure uniform flow of carburizing gas around them. The loaded fixture is arranged for charging and discharging in and out of the retorts by means of an electric hoist and monorail system. While being transferred to the heat exchangers, the hot work is protected from the air by means of a Universal metal shroud.

Allowing an average total time of six hours per charge for charging, heating up, carburizing, and discharging the various parts, the three furnaces would turn out approximately 12 charges per 24 hr.

Uniformity and improved quality of work are to be gained from the use of heat exchangers. A hot charge from a carburizing retort is placed in the hot side of a heat exchanger for cooling and a cold charge is placed on the preheating side. A motor-driven fan assists the circulation of the atmosphere up through the hot work and down through the cold work. It is estimated that equilibrium will be reached at about 750° F. when the carburized charge is removed and transferred to the reheating furnaces and the warmed charge put in a carburizing retort.

Carburized parts for quenching are reheated in rotary hearth furnaces with two-zone control. This arrangement preheats the work in the first half-revolution of the hearth and soaks it above the critical temperature in the second half-revolution.

These furnaces contain complete driving units controlled by Stromberg automatic repeating process timers, which can be set to allow for any definite time intervals from 15 sec. to 6 min. The operator will therefore discharge and charge the hearth segments as they come around and stop, and the temperature cycle is automatically maintained.

Operator Quenches Each Part

At any given stop interval, the operator is required to quench, one by one, each part on the hearth segment in front of the discharging door. Parts must be picked out with tongs and immediately transferred to a special quenching fixture where they are dropped through the high-pressure water spray and fall into the quenching tank onto a mesh conveyor. During this same stop interval, the operator must also recharge the empty hearth segment in front of the charging door of the furnace.

The above quenching fixture comprises a vertical pipe 10 in. diameter, of a convenient height for the operator, and set in the quenching tank, as shown in the general plan. At a line above where the pipe enters the water in the quenching tank, a manifold encases the pipe, which is perforated in that section. Water under pressure entering the manifold operates through the perforations in the pipe, effecting a zone of great turbulence through which the hot water must pass. The speed attained by the hot work falling with the acceleration of gravity and the velocity of the high pressure water spray both contrive to give the work a drastic quench and one that will reach every recess in the parts.

The quenching water used with this fixture as well as in the quenching tank is taken from boilers in order to assure freedom from absorbed air. Any air in the quenching water will be liberated during the quench and will serve to prevent proper quenching of the work by forming a gas blanket around the part, to the exclusion of the quenching water itself. It is also desirable, for the sake of uniformity of results, to maintain constant water temperature by means of a cooling machine.

The conveyor discharges the work out of the tank and into baskets for charging into the drawing furnaces. It is estimated that each furnace will handle 500 lb. of work per hr., or a total of 12,000 lb. of work per furnace in each 24 hr.

For the purpose of relieving quenching strains only, it is necessary to subject all treated parts to a low temperature draw. The drawing furnaces are positive displacement air machines, utilizing an impeller blade with a swing of 180°, circulating the air first in one direction through the work and then in the other.

In order to insure perfect duplication in the finished, heat treated product, automatic temperature control is used throughout.

Each carburizing furnace has three separate zones of control located, respectively, in the bottom, middle, and top of the furnace. The middle zone control is recording while the top and bottom zones are merely indicating.

Air tempering furnaces are also regulated by automatic temperature control.

It is desirable to centralize the temperature controlling apparatus by means of a panel arrangement carrying all the instruments.

The foregoing comprises a complete and versatile layout of a heat treating department capable of the highest type of metallurgical control and based on the most modern information available on the subject. Any metallurgist would consider it a pleasure to have such a plant under his supervision and would have very little hesitancy in assuming the responsibility for work passing through his department.

Correspondence and Foreign Letters

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Italy Expands Its Capacity For Aluminum

A FACT, well known in politics, whose importance in the economic field has been generally underestimated, is the influence of "ready-made sentences." They often do much harm in both politics and economics when the incompetents (who form an overwhelming majority in all the countries of the world, finding in the modern daily press a powerful means for promulgating their errors) by repeating those "ready-made sentences," make real slogans out of them, very often leading to dangerous generalizations, devoid of any basis.

One such slogan which has long plagued Italian economic and industrial life is the statement that "The want of raw materials would forever prevent a sound development of home industry."

Later, I will probably find the opportunity of showing how such a statement is totally false in a number of instances concerning many of the most important modern industries, and how, in the remaining instances, the scarcity of some raw materials in Italy is largely balanced by other favorable conditions, which enable certain industries to thrive when using some imported raw materials.

Nevertheless, the slogan "scarcity of raw materials," repeated and generalized by so-called newspaper-economists and politicians, has been accepted as a truth by the Italian public, and has long been responsible for strong antagonism to the formation of an "industrial mentality."

This situation also prevented for a long time the development of those industries for which Italy could supply large quantities of all the necessary raw materials. A typical example is the manufacture of special steels, which I have described in some detail in preceding letters.

Another example is the production of the light metals aluminum and magnesium, and the manufacture of their alloys.

All the conditions for a sound development of these last-mentioned industries exist in Italy; namely, raw materials (huge deposits of bauxite, leucite, and magnesite of the best quality), cheap power, and excellent and cheap labor. Nevertheless, only in the last four years, and with the efficient support of the present Government, which has succeeded in putting "slogans" aside, the light metals industry is beginning to develop in proportion with the requirements of our country.

Until 1928 the Italian output of aluminum hardly reached 2,000 tons per year, divided between two small plants. The first of these was installed about thirty years ago at Bussi, Abruzzi, in central Italy. The second was erected about 15 years ago in Borgofranco, Piedmont. Such an output was far below the domestic consumption of aluminum, which reached at that time about 10,000 tons a year.

During that last three years two new large plants have been put in operation, and are now producing yearly 6,000 tons each, using as raw material the bauxite from Istria, in northeastern Italy. Their capacity is now being increased.

A third and much larger plant is now under construction at Civitavecchia, about 60 miles north of Rome. It is expected to start before the

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end of this year. Its yearly capacity is twice as much as the total of the other plants. Aluminum is obtained by treating the leucite rocks, existing in enormous quantities in central Italy, and producing as a by-product large quantities of potassium nitrate by a new process invented by the Italian chemist, Dr. Blanc.

In my next letter, I hope to give a few details concerning these three plants.

FEDERICO GIOLITTI

Turin, Italy.

I WAS very much interested in reading the editorial in the January issue of METAL PROGRESS relating to the work in metallurgy at the Bureau of Standards. The analysis you made of the figures in the Director's annual report does not state the full facts concerning the Division of Metallurgy, of which I have the honor to be the chief.

Funds for Researches Into Metal

The total amount available for metallurgical work last year, was somewhat more than twice the amount stated in the editorial, $51,000, which was the amount of the specific appropriation entitled "metallurgical research". Very considerable metallurgical work was carried on under other appropriations, especially one entitled "industrial research" and another entitled "salaries." Actually, the total sum of $114,000 was available. In addition, some funds were transferred from other government departments for helping defray costs of researches undertaken at the specific request of such departments.

The number of researches in progress was 33. In the brief resume published as the annual report, those studies which have been brought to completion or those in which very substantial progress has been made naturally must be given prominence. It is not practicable to list everything under way.

H. S. RAWDON

Washington, D. C.

IN THE December number of METAL PROGRESS (page 90) was asked "Does Quenching Stiffen a Spring?" This perennial question may be classed with a number of others, such as "crystallization," "large flaws" and some others.

Stiffening Brake Beams By Quenching

F. P. Zimmerli covered it very well in that issue, but steel treaters may be interested in a rather striking practical experience. The poor metallurgist is somewhat at the mercy of the designing engineer, but on the other hand it is sometimes not realized how great are the effects of internal stresses, even in very small sections. (Mr. Merten of the Westinghouse Co. has told us about the great importance of uniform hardness in heavy coil springs — a similar effect.)

About fifteen years ago a railway company was experiencing trouble with the brakes on certain cars because the built-up brake beams lacked rigidity. A shop official conceived the idea of water quenching to harden and "stiffen" them. The writer, then Engineer of Tests, failed to convince his associate that there was no such thing, and by way of practical demonstration made the following experiment.

Four all-hard hack saw blades, $\frac{3}{4}$x11x0.046 in., were taken from a new package. They were as near alike as could be imagined. Two were packed in a pipe with mica and annealed. The hard blades scleroscoped 94 and the soft 42 to 46. All blades were in turn fixed as canti-

levers and loaded; both ends, both sides were tested. The *hard* blades deflected 6.6% *more* than the soft, a striking result of internal stress in a thin section.

Nevertheless the brake beam experiment had to be made! The only result was that some badly annealed malleable brake heads were shattered.

GORDON SPROULE
Assistant Professor, McGill University
Department of Metallurgical Engineering
Montreal, Canada.

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Testing for Acceptance or Service

QUESTIONS raised at the recent Air Safety Congress about definitions of elastic and fatigue properties of materials, raises in my opinion a problem of a more general interest, namely, the relationship between physical tests as made by metallurgists and the characteristics of the same materials required in the computations of designers. Very often researchers who study metal, metallurgists who make the metal, and engineers who design the machinery and buildings do not speak the same language, either because the required characteristics vary as the point of view varies, or because the same words do not always mean the same things to each of these men.

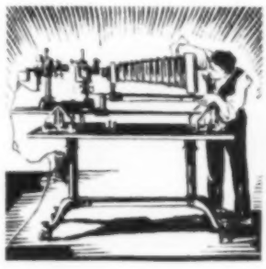
If we survey all the physical tests now used to measure the durability and the fatigue properties of material, we may divide them into two classes — identification and service tests.

Identification tests are those which aim at an experimental definition of certain quantities or coefficients called "physical properties", such as ball hardness, ultimate tensile strength, or impact strength. Such characteristics are used as a basis for specifications governing sale, purchase, or acceptance of metals intended for engineering use. The above properties are conventional or arbitrary, in the sense that they enable us to classify metallic materials, and to determine whether deliveries are of uniform quality. We must not expect more from them.

Most of these identification tests cannot be used in designer's computations wherein the "elastic limit" is the real limiting quantity. It must also be noted that elastic stresses derived from most design formulas hold little relationship to the elastic limit experimentally found for the metal from which the pieces are made. This is taken care of by designers by introducing an arbitrary coefficient (called the factor of safety) *not*, as is frequently said, to take care of variations in test methods, physical blemishes, and so on, but in truth to disguise the uncertainties and inadequacies of the computation formulas. Truth to say, these computations make no account of impacts, vibrations or erection stresses (sometimes of considerable size).

Recognizing these limitations, acceptance or identification tests must be accurate, rapid, economical, capable of being duplicated, and of a nature similar to the expected duty of the material. For instance, it would be absurd to test a steel in compression which is to be made into wire and which will work in tension, and no less absurd to make tensile tests on gray pig iron which will withstand bending and compression stresses.

The second main class — service tests or fatigue tests — aims to reproduce conditions under which the parts will work. To that end the metal is submitted to alternating stresses, vibrations, and repeated impacts. Such loads are the chief causes of fracture in service, as is shown by the similarity existing between appearance of surfaces broken in service and those broken in tests of this kind. On the contrary, the fractured surfaces of bending or im-



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pact test pieces are never found in pieces broken in service.

Service tests enable the engineer to compare and to classify materials for definite services. Unfortunately, they require more care than acceptance tests, since the causes of errors are more numerous and important, and they take much more time, since they are made to discover the most resistant metal for a definite service. Furthermore, I believe that a metal can only be qualified after several tests made under sundry stresses.

Take as an example, a notched test piece receiving blows alternately on two opposite faces from a weight falling from a certain height h. The number of impacts n to fracture will be represented (for a group of materials of similar properties) as a function of h plotting as a straight line on logarithmic paper. The formula is $h = a \log n + r$.

Thus, any correct comparison between two similar materials must be made by means of the two coefficients a and r, instead of the number of blows corresponding to an arbitrary height of drop.

It takes a very long time to determine the coefficient a in the above equation. Moreover, the determination of the fatigue limit by means of alternate or rotary tests requires a numerous series of tests under decreasing loads and takes a long time. For such reasons, the aim of modern research is

1. To find a fatigue value which appraises the quality of materials in service, and

2. To correlate this fatigue limit and the physical properties given by acceptance tests.

ALBERT PORTEVIN

Paris, France.

Dr. Honda Honored for Inventions

THREE different notes on three different aspects of metallurgy in Japan may be interesting to American readers.

First concerns the merger of various Japanese iron and steel works. Like other countries in America and Europe, we are now suffering a great economic depression. To meet this condition, "rationalization" in every direction has been contemplated, and certain plans are now being carried out. Formation of a great company, including nearly all of our principal iron and steel works, is in the way of completion. According to reports, this merger will be formed under the following conditions:

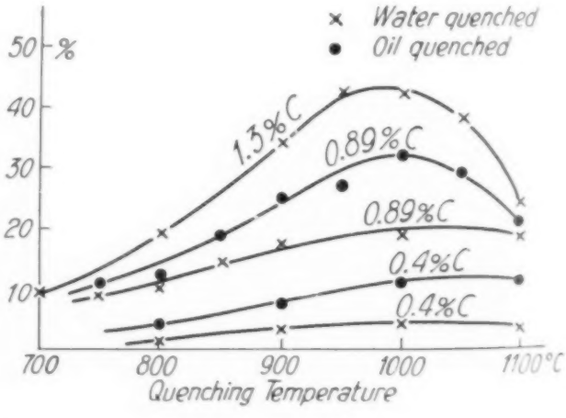
1. For the rationalization of iron and steel works, Yawata Imperial Steel Works and all other private works will unite into a large private company.

2. Each company will contribute its own property as a capital to the new co-operation. The estimate of the value of this property will be made by joint representatives.

3. The government has a chartered right of priority on all matters and products concerning the national defence.

The second note has to do with K.S. magnet steel (cobalt-tungsten-chromium).

On December 11 last, His Majesty the Em-

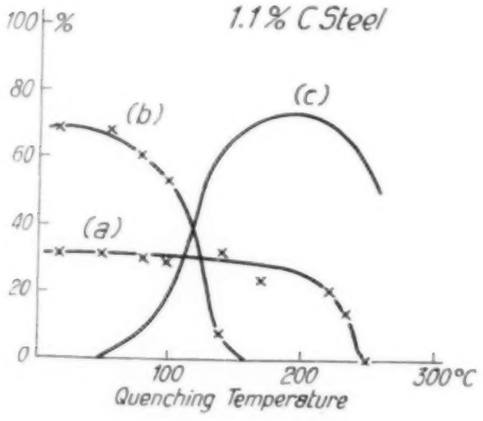


Retained Austenite in Hardened Steels Is Maximum in Amount After Quenching From About 1000° C.

peror of Japan, in honoring for the first time ten inventors, gave them a dinner in his palace. His Imperial Highness Prince Kanin, the prime minister, and two other ministers were present at this function. It has undoubtedly stimulated inventive activities. In the field of metallurgy, "K.S. magnet steel" (or "cobalt steel" as it is sometimes called) was one of the ten inventions honored on this memorable occasion.

This steel is now widely used in America and Europe for telephone parts, radio parts, and precision electrical instruments. Western Electric Co., Westinghouse Electric & Manufacturing Co., and many other factories have been using this steel for some years. The tonnage exceeded 50 tons last year.

K.S. magnet steel, as described by me in the original disclosure of the invention, contains as its main constituents 30 to 36% of cobalt, 6 to 8% of tungsten, 1 to 2% of chromium and 0.7 to 1.0% of carbon. Its coercive force is very large (about 220 c.g.s. units), more than three times that of ordinary tungsten steel, and consequently it is exceedingly permanent. The permanent or residual magnetism of a magnet depends of course on the ratio of the length to its cross section. In a very long magnet, the permanent magnetism of K.S. steel is only a few per cent greater than that of the tungsten steel, but it increases rapidly as the dimension ratio decreases. For example, in the dimensions commonly used as a magnet (such as a magnet 12 times as long as its diameter) the permanent magnetism of K.S. steel is more than twice that of tungsten steel.



Relative Amount of Micro Constituents In 1.1% Carbon Steel, Quenched in Water from 900° C., After Various Temperings. Curve a represents amount of retained austenite; b charts the amount of alpha-martensite; c is the amount of beta-martensite

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As the price of pure cobalt is at present very high, K.S. magnet steel itself costs about eight times that of tungsten steel. But since its permanent magnetism is very large, the dimensions of the magnet can be much reduced, and consequently the surrounding parts, that is, other instrument parts and cases, can also be reduced in dimensions, so that by using K.S. magnet steel the total cost is much lower than when using tungsten steel magnets. Furthermore, an instrument with a great permanency can be constructed at a moderate price.

Thirdly, I would call your attention to recent quantitative measurements of austenite and martensite in quenched carbon steels, and the change of these quantities by tempering.

Messrs. S. Sekito, K. Tamaru and the present writer devised a new method of measuring the quantity of retained austenite and martensite present in quenched steels by means of X-ray analysis. One-third of the surface of the specimen wire was covered longitudinally by a thin gold strip and the X-ray photograph was taken with the wire continuously rotating. The film contains the spectral lines of both gold and the test-specimen. The relative intensity of these lines in the film was determined from the height of the curve recorded by a micro-photom-

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eter, one and the same line on the gold spectrum being taken as the standard of reference. Thus the intensity of the austenite and martensite lines in different films (and consequently their percentage contents) can be compared with each other. The height of the curve corresponding to 100% austenite was obtained from an austenitic manganese steel.

If the test-wire be too thin, the ratio of the surfaces of the specimen and the gold cannot be accurately measured. Hence the diameter of the wire was taken at 5 mm. The wire was placed so that the surface of the wire during rotation always passed through the center of the camera, at which a narrow beam of X-rays impinges.

Not only the quantity of retained austenite in carbon steels quenched from different high temperatures was measured, but also the change of the quantity of retained austenite and martensite after quenching. Results are shown in the diagrams on the two preceding pages.

It is a well established fact that a tetragonal martensite (α-martensite) exists on the surface of a quenched steel, and in its interior a cubic martensite (β-martensite) is present. From one set of curves it is seen that the amount of retained austenite increases with the quenching temperature, reaches a maximum at about 1000° and then decreases. This decrease is very probably due to the accelerating action of thermal stress on the austenite to martensite transformation during quenching. The important fact that the retained austenite is decidedly greater in the oil-quenched specimens than in the water-quenched ones, is also explained in the same way by the thermal stress.

From curve *a* in the other figure we see that in a 1.1% C steel quenched at 900° in water, the retained austenite remains almost unchanged during tempering for 30 min. up to 200°, and then begins to decompose, completing its decomposition at about 240°. In the same figure, curve *b* shows the quantity of alpha martensite; it begins to change into β-martensite at about 80° and completes its change at 170°. Since the quantities of austenite, α- and β-martensites form 100 per cent, the quantity of the latter martensite can be obtained from those of the former two. Curve *c* in Fig. 2 shows percentage content of β-martensite thus obtained.

K. HONDA

Sendai, Japan.

Rapid Carbon Estimation In Refining Stage

WHEN following the process of refining during the course of a heat, the open-hearth melter usually resorts to one of various rule-of-thumb tests for estimating the carbon content of the metal. While such tests in the hands of a skilled workman give fairly accurate results, there will always remain a certain element of uncertainty. Chemical determination of the carbon content by means of combustion is certainly accurate enough, but it requires too much time to hold the heat.

An instrument, which, when correctly handled, gives exact information about the carbon content of the steel bath in 2 to 3 min., should therefore be heartily welcomed. Such an instrument has been invented by Gunnar Malmberg, then of Kohlswa Jernverks, now chief metallurgist of the Surahammars Bruks, a well-known steel works in central Sweden.

This instrument, which is called a "carbometer," was invented about 18 years ago and has been thoroughly tested both at Surahammar and at several other Swedish steel works, as well as on the continent. A detailed description of its construction and use has never been published until quite recently, and so far only in Swedish in the venerable mining and metallurgical journal *Jernkontorets Annaler*.

The carbometer operates on the following principle: When a steel specimen is alternately magnetised by means of two magnetic fields of

different but constant strength, the induced magnetism of the test piece assumes a constant value, for each of the fields applied. The difference between these values is the quantity measured in the carbometer.

Testing is done in the following way: A quantity of molten steel is taken out of the furnace with a spoon and poured into a mold after a fixed amount of aluminum has been added as a deoxidizer. The small ingot obtained, which has the form of a cylindrical bar about 0.5 in. diameter, is either hardened by quenching in water or, if the carbon content is low, is left in the mold for one minute while cooling through the critical range. The test piece is then inserted into the instrument.

By turning a handle and pressing a button a spring is released, which drives a rotor, causing the test piece to be alternately influenced by a stronger and a weaker magnetic field. After about 8 sec. the rotor stops, and when a second button has been pressed the "carbometer value" is immediately obtained from a galvanometer reading. The carbon content of the test piece is obtained from a diagram, where the percentage of carbon has been plotted against carbometer reading. The diagram contains two different curves, one for quenched steels and one for those more slowly cooled. Casting and the handling of the mold require a certain manipulative skill, and choosing the right moment for the quench needs some training. Manganese, silicon and other elements do of course also influence the magnetic properties of the steel. As however the content of the two first named elements is always low and fairly constant during the period of decarburization, and as the content of eventual alloy metals is generally known, corrections can be made.

Such an instrument is especially useful for the production of a uniform quality of tonnage steel. The reliability under such conditions is illustrated by the following example, cited by the inventor, Mr. Malmberg: The carbon content was accurately determined from ladle samples of 271 heats of a standard steel made with the help of this instrument. The range aimed at was carbon 0.60 to 0.65%. The range was hit 93% of the time. It was missed one point 5.5% of the time (0.59 C 1.8%; 0.66 C 3.7%) and missed two points 1.5% of the time (equally divided between 0.58 C and 0.67 C).

EINAR ÖHMAN

Stockholm, Sweden.

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Pioneers in Induction Melting

THE editorial which appeared on pages 68 and 69 of the February 1931 issue of METAL PROGRESS telling of the development of the high frequency induction method of heating contains certain omissions which you will, no doubt, be glad to carry as an additional note.

The Babcock & Wilcox Tube Co. had an Ajax-Northrup furnace for making castings almost three years before similar type furnaces were installed at the plant of the Lebanon Steel Foundry and at the Duriron Co.

About a year ago a 600-kw. outfit was installed at the Bethlehem plant of the Bethlehem Steel Co. for pouring tool steel ingots. At the time this equipment was ordered, the largest American steel melting equipments of this type already installed were high frequency induction furnaces of 150-kw. rating.

DUDLEY WILLCOX

Trenton, N. J. Ajax Electrothermic Corp.

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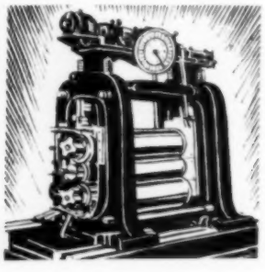
IT IS well known to spring makers and others that the resistance of steel to fatigue may be seriously reduced by the process of electroplating with nickel or other metal as a protection against corrosion. For this reason japanning is frequently used for springs where electroplating would have decided advantages.

Endurance of Electroplated Parts Studied

The effect is often due to hydrogen embrittlement, caused by the pickling process, but even when precautions are taken to eliminate that defect a reduction of the fatigue range is observed. This behaviour of electro-deposited metal has been investigated by R. H. D. Barklie and H. J. Davies in the University of Sheffield, and their results have been published in the form of a paper communicated to the Institution of Mechanical Engineers.

As far back as 1877, it was shown by Mills that electro-deposited metals are commonly in a state of stress, and later workers, especially Kohlschütter, have determined the factors which affect the amount of stress. In the present experiments, most of which relate to deposits of nickel on steel, the stress was measured by plating on one side only of a strip and observing the curvature by an optical method.



Mild steel test pieces in simple tension are, as might be expected, practically unaffected by coating with a deposit of nickel, but the effect on the resistance to fatigue, as tested on a machine of the Wöhler type, is quite different. While the safe fatigue range of the unplated steel was ± 34,000 lb. per sq.in., this was reduced to ± 23,000 lb. by a coating of electrodeposited nickel 0.001 in. thick.

Since the fatigue range of nickel is close to that of steel, the result cannot be attributed to any inherent weakness in the deposit. A similar deposit was found, however, to have an internal stress of 26,000 lb. per sq.in., the nickel being in tension. If this stressed deposit be then subjected to alternating tension and compression, as in the Wöhler test, this stress is added to the stress in the tensile phase of each cycle, and the strength of the coating is exceeded. It cracks, and the cracks may propagate themselves into the steel beneath.

The formation of cracks during the test was proved by means of the ferroxyl reagent. No blue stains were obtained when this reagent was applied to the test piece at the beginning of the test, but as it progressed fine transverse cracks made their appearance.

It was proved in the course of the work that the stress in deposited nickel increases in proportion to the deposition potential. By superposing alternating current on the direct current ordinarily used in plating, the metal may be deposited at a potential lower than usual. Making use of this observation, nickel was deposited under such conditions as to be nearly free from stress. Steel test pieces plated in this way gave a fatigue range of ± 32,000 lb. per sq.in., which is very near to the value for the unplated steel.

The method of plating was to pass the direct current used for the deposition through the low-voltage windings of a transformer, while alternating current from the mains was passed through the high-voltage windings. This process is recommended for thick deposits, such as are used for building-up, in repair work. Care must be taken in the cleaning of the steel that the methods employed are not such as to cause hydrogen brittleness.

A curious fact is that the Brinell hardness of the unstressed deposit is less than that of one prepared in the usual way.

The reduction in the resistance to fatigue increases as the deposit becomes thicker. A sharp V-groove in a steel specimen, equal in depth to the thickness of an electro-deposited coating, reduces the strength in about the same degree as the deposit.

Lead coatings, being of an exceedingly soft metal, do not reduce the fatigue strength of steel to any appreciable extent. This fact suggested the idea of interposing a thin layer of lead between the steel and the nickel, and this device proved to be successful in preventing the propagation of cracks. So thin a coating of lead as 10 millionths of an inch is found to serve the purpose. This simple plan should be useful in practice.

Zinc, when deposited electrolytically, is usually in a state of slight compression, while most metals resemble nickel in being deposited under tension. In accordance with this fact, a coating of electro-deposited zinc does not lessen the resistance of a steel test piece to fatigue.

C. H. Desch

Sheffield, England.

Correspondence and Foreign Letters

Metals Used In Building Airship Do-X

ON THE last day of January the flying ship Do-X started on a trans-Atlantic flight. The inventor and designer of this remarkable vehicle is Dr. Claudius Dornier of the Dornier-Metallbauten, Friedrichshafen.

There has been an enormous amount of developmental work behind the first flight of this giant of the air. Several smaller aircraft of similar design as the Do-X had been built since 1919. First sketches for an airship that later developed into the Do-X were drawn up in 1924. The next two years were devoted to a thorough study of every detail. From results so obtained the final drawings were started in the middle of 1926 and completed in about six months. Another year was spent in going over every detail, such as building models on a small scale for tests in wind tunnels, and other preliminary work. For instance, a full-sized model of the boat and the main body was built in wood in order to enable the designers to judge if all proportions were well chosen.

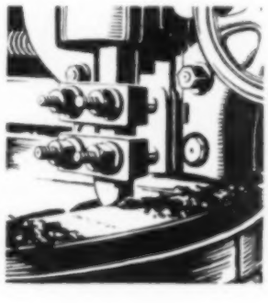
Actual construction work was started in December 1927. Two years later the flying ship was completed and ready for the air.

The main dimensions of the Do-X are: Wing spread 157 ft., wing height 31 ft., and length 132 ft. The carrying surface of the wings is nearly 5,000 sq.ft., the normal flying weight when starting 48 tons, and the carrying capacity is 22 tons. In one of the first flights no less than 170 persons were taken aloft.

The Do-X is equipped with 12 water cooled 12-cylinder Curtis-Conqueror motors. These are placed in pairs, one before the other, in six motor gondolas placed above the wings. As each motor drives one propeller, two parallel rows of six propellers each are obtained. Each motor has a 600-hp. capacity, so that the total strength of the motors is no less than 7,200 hp.

Considering a power plant of this size, the difficult conditions of service, and the extreme necessity to keep every part as light as possible, it is easily realized that all the materials of construction will be quite highly stressed. The biggest difficulty, perhaps, is that it is frequently impossible to calculate these stresses.

The heaviest forces and stresses occur when the airship is lifting from and alighting on the water, and are in the length direction of the



Correspondence and Foreign Letters

boat. In order to take up these stresses two U-beams run fore and aft. These beams have the dimensions 120 x 50 mm. and are 4 mm. thick ($4\frac{3}{4}$ x 2 in.; $\frac{5}{32}$ in. thick). The material used is a chromium-nickel steel bought to the following chemical specification:

Carbon	0.20 to 0.27%
Nickel, about	3.5 %
Chromium	0.75%
Manganese	0.4 to 0.8%
Silicon, less than ...	0.35%

After annealing the tensile strength is about 114,000 lb. per sq.in., and the elongation 20%.

With the exception of these two beams and a very few smaller parts made of the same steel, the main construction material is duralumin. Wing covering is partly duralumin sheets and partly airplane linen.

Although the physical properties of the duralumin alloys are well known from the extensive research work necessary for their development, it was uncertain whether the known values in regard to strength and elongation could be used in calculating the stresses in the large profiles and assemblies chosen for the construction of the Do-X. It was therefore deemed necessary to perform special tests on different members.

The three duralumin beams around which the wings are built look very simple when completed, but they represent the result of 3 or 4 months' tests with different designs. Preliminary tests with minor loads were accomplished by means of sandbags and scrap iron, but when testing the Do-X wings with loads of 42.5 tons huge containers were attached to the panel points. These containers were filled with a varying amount of water and the elastic movement of the members were measured.

Two types of duralumin have been used. For pressed beams duralumin of specification 681 Z B is employed and for cold drawn parts, as well as for covering sheets, duralumin 681 B $\frac{1}{8}$. Both these alloys contain: 3.5 to 5.5% of copper, 0.25 to 1% of manganese, and about 0.5% of magnesium.

Physical properties guaranteed by the manufacturer, Dürener Metallwerke, are as follows:

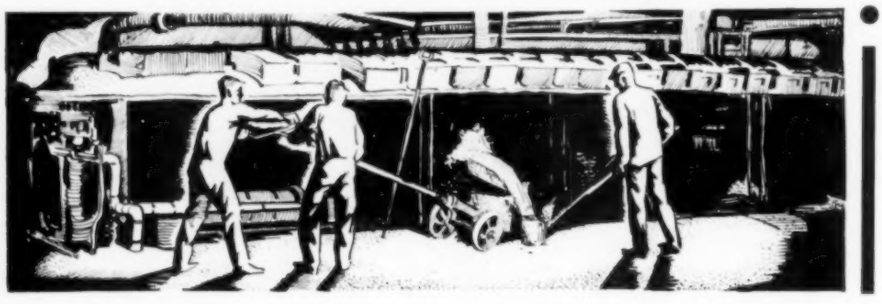
Duralumin	681 Z B.	681 B $\frac{1}{8}$
Elastic limit	42,600	35,000 to 40,000
Tensile strength	62,600	54,000 to 58,300
Elongation	14%	18 to 21%
Specific gravity	2.8	2.8

Duralumin parts are joined by rivets of the same alloy. For joining steel parts, or for joints between steel and duralumin, steel rivets are employed. Bolts and nuts are also used.

The Do-X built in 1929 has a lifting power of 22 tons, as noted, in excess of its own weight. The maximum in an airplane in 1918 was 3.7 tons. The Do-X is, however, according to Dr. Dornier, only a step in the direction of much bigger flying ships and he considers the biggest importance of the Do-X as showing the way how to build flying ships with a lifting power of 100 tons or more. With planes of this size a service covering the whole world should be possible.

E. W. Ehrs

Cannstatt, Germany.



SIMONDS

Airplane View
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Mill

High Speed Steel **Carbon Tool Steels**

Cobalt Magnet Steel

Tungsten Magnet Steel

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Heat Resisting Alloys

Special Grades for Electric Purposes

Low expansivity (minimum coefficient) types

Stainless Steel **Stainless Iron**

Sheets **Bars**

Cold Rolled Strip

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Reviews of Recent Patents

By Nelson Littell
475 Fifth Avenue
Patent Attorney
Member of A.S.S.T

Hard Alloy Steel, *by Shelley M. Stoody, of Whittier, Calif., assignor to Stoody Co. 1,790,177; Jan. 27.*

This alloy steel has great hardness and toughness and also a stable surface quality, being acid, heat, and abrasion resisting. It contains carbon, chromium, silicon, nickel and iron. With chromium between 25% to 35% an alloy is produced which is particularly suitable for cutlery, tool steel and welding rods. The preferred composition is 2% carbon, 31.75% chromium, 10% nickel, 4.75% silicon, and the balance principally iron. Such an alloy has a hardness of Rockwell C40 to 45 and has a melting point from 2700 to 3000° F.

Alloy Cast Iron, *by Augustus F. Meehan, Chattanooga, Tenn., assignor to Meehanite Metal Corp. 1,790,552; Jan. 27.*

This invention relates to the treatment of gray iron castings are treated by the addition of a suitable agent to obtain the carbon in the desired forms, particularly for the improvement of the character of the castings. An alloy comprising silicon in not less than approximately 50%, an alkaline in excess of 25%, nickel approximately 5%, and a second alkaline metal of the calcium-magnesium group in a percentage somewhat less than one-half the percentage of the first alkaline metal, is particularly desirable and will produce an appreciable graphitizing effect.

Foundry Facing, *by Benjamin F. Wallace, of Brooklyn, N. Y. 1,787,964; Jan. 6.*

The purpose of this invention is to cast metals in sand molds without cutting, washing, etc., and with smooth, fine-grained surfaces free from pin holes and completely free from burnt-in sand. The use of graphite has been known but the application of such material is often more expensive than sand blasting or pickling. The present facing composition contains a major percentage of coke in finely divided condition, the particles being coated with a water soluble defloculating agent such as dextrin, gelatin, etc., and further mixed with a colloidal clay like of bentonite and having a dye absorption figure in excess of 1500.

Steel Refining Process, *by Sigurd Westberg, Germantown, Pa. 1,786,806; Dec. 30.*

By this process a highly purified ferrous material is made which is substantially free from manganese, carbon, oxygen, sulphur, and phosphorus. The initial charge is of Bessemer or open hearth steel, highly oxidized, containing an amount of carbon, manganese or silicon approximating 0.1%. Hydrogen or a gas containing hydrogen is continuously introduced over the metal or bubbled into the metal so that all gases containing oxygen are excluded. There is an excess of hydrogen so that the gaseous products of the reaction are continuously removed from the furnace. A strongly basic material such as lime is used as a slag and reacts with the products of the combination of the impurities and hydrogen. Finally hydrogen is regenerated by causing the impurities to react with an alkaline earth metal and a silicide of zirconium, aluminum or manganese.

(Continued on page 98)

LOCAL TELEPHONE SERVICE ONCE COST

$240 A YEAR

In 1879, the New York telephone directory was a card listing 252 names. There were no telephone numbers, nor any need for them. When you telephoned, you gave the operator the name of the person you wanted. Service was slow, inadequate and limited principally to people of wealth. The cost of a single telephone was as high as $240 a year.

Today, you can talk to any one of hundreds of thousands of telephone users for a fraction of what it then cost for connection with less than three hundred. Every new installation increases the scope and value of the telephones in your home or office.

Twenty-four hours of every day, the telephone stands ready to serve you in the ordinary affairs of life and in emergencies. In the dead of night, it will summon a physician to the bedside of a sick child. Men transact a great part of their business over it. Women use it constantly to save steps and time in social and household duties. In an increasing number of ways, it helps to make this a united, more active, more efficient nation.

Simply by lifting the receiver you become part of a nation-wide communication system that uses 80,000,000 miles of wire, and represents an investment of more than $4,000,000,000. Yet the cost of local service is only a few cents a day.

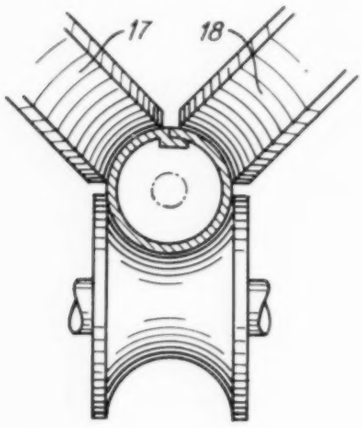
Subscribers who look back over the month and consider what the telephone has meant to them in convenience, security and achievement are quick to appreciate its indispensable value and reasonable price.

Frequently you hear it said—"The telephone gives you a lot for your money."

★ *AMERICAN TELEPHONE AND TELEGRAPH COMPANY* ★

Electric Welding, *by John F. Lawson, Brooklyn, N. Y. 1,786,759; Dec. 30.*

This patent relates to autogenous electric welding of long seams such as in the formation of pipe. Autogenous line butt welding is accomplished by bringing opposed surfaces of the metals into contact with each other and applying electrodes to the same surface of the metal parts so the electrode pressures are not opposed to each other, the welding pressure being applied at some distance from the heat which is located between the electrodes. In the present apparatus one edge of the strip is formed with a depressed section, the depression being equal in depth to the thickness of the strip. The strip is then formed into a tube and the strip overlaps the depressed section and abuts the shoulder. As shown in the drawing, the electrodes *17* and *18* contact with the respective ends of the pipe and form a tightly filled tube without a central ridge and with a reinforced overlap on the interior, a feature which is claimed to add strength.



Cyaniding Apparatus, *by Heyman Rosenberg, New York, N. Y. 1,786,508; Dec. 30.*

The apparatus commonly used for cyaniding small parts is difficult to operate and frequently dangerous. This invention cyanides and quenches without transferring the material through the air or into the open shop. A furnace and vat are combined with a work carrier for moving the work to and from the vat and to and from a discharging position beyond the vat. A hood seals the entire apparatus.

(Continued on page 100)

The VICKERS HARDNESS TESTING MACHINE

. . . provides a proportional and absolute standard of hardness by the plastic indentation method. There is nothing empirical about it. It will test difficult specimens such as sheets under .007" thick; gear teeth on the working face; finished coil springs, etc., without damage. It is semi-direct reading and very fast...In research work into the constitution and properties of nitrided steel cases, after a trial of other Hardness Testing Machines, this machine was selected as the most suitable, as besides the hardness, it indicates the friability of the case, which is a measure of its wearing qualities.

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CHROMIUM

High-Carbon Ferrochrome
(maximum 6% carbon)
Low-Carbon Ferrochrome
(in grades, maximum 0.06%
to maximum 2.00% carbon)
Chromium Metal
Chromium-Copper
Miscellaneous Chromium Alloys

▼

MANGANESE

Standard Ferromanganese
78 to 82%
Low-Carbon Ferromanganese
Medium-Carbon
Ferromanganese
Manganese Metal
Silico-Manganese
Manganese-Copper
Silico-Spiegel
Miscellaneous Manganese Alloys

▼

SILICON

Ferrosilicon 15%
Ferrosilicon 50%
Ferrosilicon 75%
Ferrosilicon 80 to 85%
Ferrosilicon 90 to 95%
Refined Silicon
(minimum 97% Silicon)
Calcium-Silicon
Calcium-Aluminum-Silicon
Calcium-Manganese-Silicon
Silicon-Copper
Silico-Manganese
Miscellaneous Silicon Alloys

▼

TUNGSTEN

▼

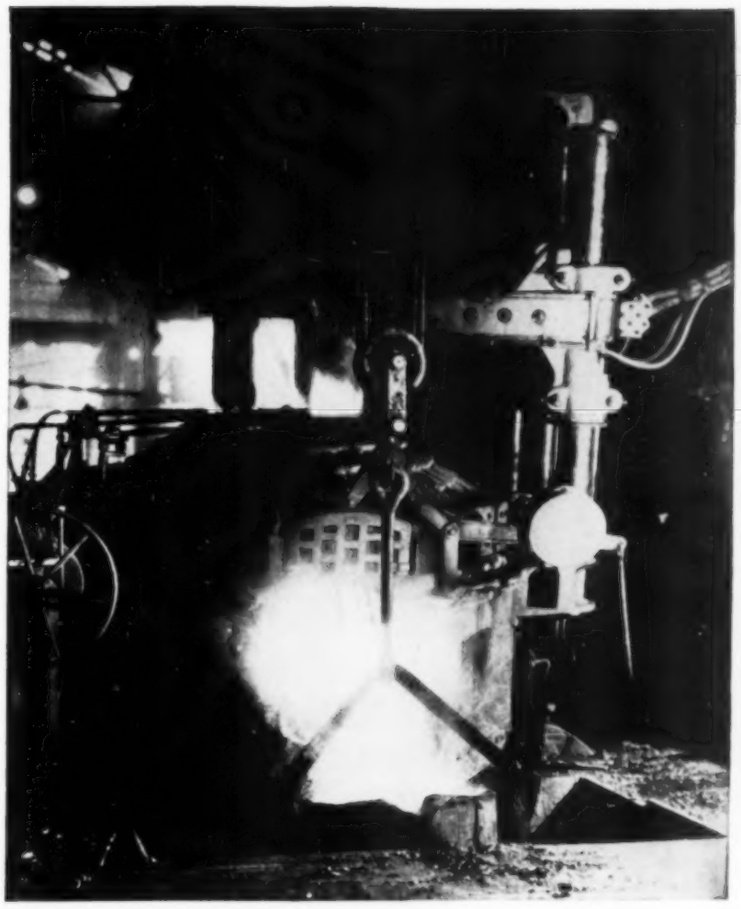
VANADIUM

All Grades

▼

ZIRCONIUM

Aluminum-Zirconium
Ferro-Zirconium
Silicon-Zirconium
Zirconium-Ferrosilicon



Zirconium for Deoxidizing High-Chrome-Nickel Castings

THE value of Zirconium in the deoxidation of high-chrome-nickel acid and heat-resisting castings is rapidly attracting the attention of foundrymen. Zirconium treatment counteracts the effect of sulphur, reduces grain size, eliminates segregation of impurities at grain boundaries, improves density and produces more uniformly satisfactory castings.

It will pay you to investigate fully the advantages to be obtained through the proper use of Electromet Silicon-Zirconium and Zirconium-Ferrosilicon. Write for complete information and arrange for a demonstration in your own plant.

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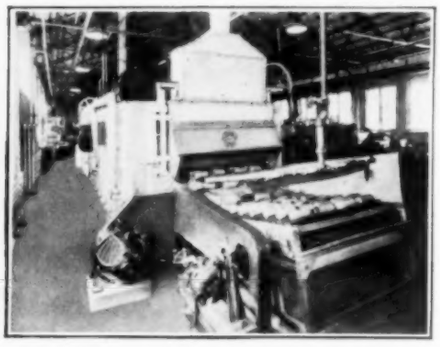

Heat-Treating Ferrous and Non-Ferrous Metal Parts . . . without Trays

in a manner that permits of individual exposure and continuous charging and discharging of the unit pieces is but one of the many features offered in the furnace illustrated above.

Stock to be heated may be charged at random, movement through the furnace without distortion being accomplished with a special form of alloy metal conveyor. Heated stock may be delivered to a shower or bath for cooling from inside the furnace chamber or through the working opening.

In economy of operation and quality of heat-treated product this furnace has shown marked superiority over methods previously employed and we would welcome an opportunity to tell you more about it.

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Member of National Electric Manufacturers Association.

Electrically Welded Vessels, *by Richard Stresau, of Wauwatosa, Wisconsin, assignor to A. O. Smith Corp., of Milwaukee. 1,784,080; Dec. 9.*

This patent describes a method of electrically welding pressure vessels such as those used in oil cracking industries. The method of manufacture prevents the setting up of excessive stresses during the fabrication of the vessel and which will substantially relieve the stresses which may have been set up. The method consists in annealing the metal plates from which the vessel is to be made, preferably to a temperature of 1550°F., rolling said plates into rings during annealing while the metal thereof is soft, electrically welding the longitudinal meeting edges of each ringed plate, heating the welded rings to an annealing temperature of approximately 1200°F. to true the circular dimensions of the ring, electrically welding the rings end to end to form an integral tubular structure, closing the end of the structure, and finally heating this closed structure to a temperature approximately 900°F. which is approximately sufficient to relieve the stresses set up during the forming and welding operation.

Heat Resisting Alloy, *by Benno Strauss, Essen-Bredeney, Germany, assignor to Fried. Krupp Aktiengesellschaft. 1,787,403; Dec. 30.*

This steel alloy is for use in the conversion of oil residues to gasoline in which steel vessels are exposed to the action of the products of decomposition of the oil at temperatures as high as 550°C. and pressures up to 70 atmospheres. It is found that an alloy containing about 0.15% of carbon, 6% of chromium, 0.3% of vanadium and 2% of nickel is particularly well suited for such vessels which do not become short even when exposed to high temperatures

Inhibitor, *by Frank D. Burke, Rocky River, Ohio, assignor, to the Passivation Products Co., Cleveland. 1,789,805; Jan. 20.*

This inhibitor is planned to reduce the injurious effect of pickling solutions. It consists of a small amount of hydrolyzed animal proteins, including the albuminoid keratin. A satisfactory pickling bath includes 5% solution of sulphuric acid to which is added 2% by weight of the regulator.

For the first time . . . .

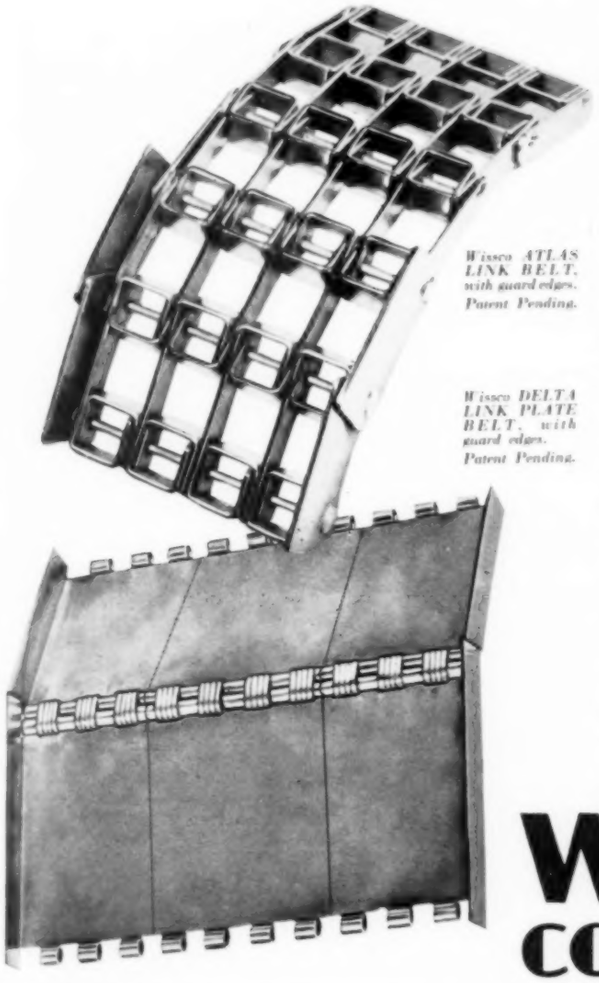
No class of materials is barred

WISSCO METAL CONVEYOR BELTS

Materials	Services
Bolts, Nuts, Rivets	Heat Treating
Machine Parts	Baking
Glassware	Drying
Roller Bearings	Washing
Springs, Wire	Carburizing
Forgings	Nitriding
Castings	Spraying
Pigments	Annealing
Fibre	Bluing
Tobacco	Drawing

Performance

Low First Cost	Greater Production
Minimum Upkeep	Reduced Operating
Faultless Operation	Costs
	Uniform Results



Wissco ATLAS LINK BELT, with guard edges. Patent Pending.

Wissco DELTA LINK PLATE BELT, with guard edges. Patent Pending.

SINCE continuous heat treating by conveyors first began, every commercial metal conveyor belt has had certain definite limitations in the matter of class of materials to be handled . . . . until the advent of the Wissco Atlas Link and Delta Link Plate belts. Now no class of materials is barred, from the smallest parts to the bulkiest materials.

Both belts can be furnished in any metal or metal alloy, in all widths and lengths, with or without guard edges. Both are remarkable for their ability to operate under high temperatures at high tensions and under heavy load for long periods of time with practically no elongation. Side travel tendencies are avoided.

ATLAS Link Belt is of entirely new construction, so designed as to prevent any possibility of pin-shear. It is a heavy duty belt unlimited in capacity to convey the heaviest and bulkiest materials through continuous heat-treating operations.

DELTA Link Plate Belt is an extremely rugged general conveyor particularly adapted to carry small parts. It is constructed of flat plates with a new, patented, non-freezing Delta Link which cannot collapse or bind the pin and insures free articulation at maximum loads and temperatures.

Write for detailed information to Wickwire Spencer Steel Company, 41 East 42nd Street, New York City.

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WISSCO CONVEYOR BELTS

Method for macro-etching tin-base babbitts of various compositions to investigate causes of connecting-rod bearing failures; microphotograph illustrates crystal structure in centrifugally and die-cast main and connecting-rod bearings.

Procedure in Preloading, H. W. Holdsworth. *Am. Mach.*, vol. 74, no. 7, Feb. 12, 1931, pages 269-272, 5 figs.

Determination of load distribution, and total actual deflection caused by external load, by use of deflection curves; sketches illustrate application of pre-loading principle in ball-bearings spindle mount design; chart shows graphically how initial preload actually reduces deflection under operating conditions.

Bearing Properties Affected by Variations in Composition, C. Upthegrove. *Foundry*, vol. 59, no. 1, Jan. 1, 1931, pages 72-74, 1 fig.

Abstract of paper indexed in Engineering Index 1930, from Am. Soc. Testing Matls. (Symposium on Developments in Automotive Materials), Mar. 19, 1930.

BALL. Theory and Practice for Machine Parts, Especially Ball Bearings (Teori Och Praktik Vid Maskinelement, Speciellt Kullager), A. Palmgren. *Teknisk Tidskrift (Stockholm)*, vol. 60, no. 46, Nov. 15, 1930 (Mekanik), pages 150-152.

No satisfactory theoretical formulas for dimensioning of ball bearings have yet been found; tests show that performances obtained from ball bearings sometimes deviate considerably from what was expected by theoretical computation.

NEEDLE. Needle Bearing (Les roulements à Aiguilles), Pitner. *Technique Automobile et Aérienne (Paris)*, vol. 21, no. 151, 1930, pages 107-111, 7 figs.

Principles of operation and design; data on load, speed and play, etc.; application in automobile design, particularly engine and transmission, are illustrated.

ROLLER. Electric Heat Treating of Roller Reduces Cost, E. V. Blanchard. *Iron Age*, vol. 127, no. 2, Jan. 8, 1931, pages 172-175.

Doubling floor space of its heat-treating department and installing electric furnaces enabled Bower Roller Bearing Co. to handle five times volume of work formerly done, at smaller unit cost; greater uniformity of heat treatment also has been attained.

BRONZE

The Metallurgy of Bronze, H. C. Dews. N. Y., Isaac Pitman & Sons, 1930, 147 pages, illus., diagrs., tables, $3.75.

Brief summary of theoretical and practical knowledge of metallurgy of bronzes, with particular reference to problems that confront foundrymen; cast structure of bronzes and their properties are described; effects of lead, nickel and minor constituents, and of gases and casting temperature are discussed; chapters are devoted to foundry practice and to segregation and liquidation.

The Effect of Additions of Small Percentages of Nickel to a Copper Tin Bronze, C. Upthegrove, G. Wilson and F. N. Rhines. *Am. Soc. Testing Matls.—Proc.*, vol. 30, pt. 2, June 23-27, 1930, pages 512-519 and (discussion) 520-521, 5 figs.

Results of laboratory study; substitution of small percentages of nickel for copper results in marked changes in microstructure, 1 per cent causing disappearance of alpha of eutectoid and appearance of dispersed constituent in alpha matrix; in cast alloys annealed for 120 hr. at 800 deg. cent., substitution of nickel for copper results in continuous increase in hardness for alpha constituent, while in constituent corresponding to delta decrease in hardness followed by increase is found.

CADMIUM

Roentgenographische Untersuchungen am System Cd-Mg (X-Ray Study of the Systems Cadmium-Magnesium), U. Dehlinger. *Zeit. fuer Anorganische und Allgemeine Chemie*, vol. 194, no. 2-3, December 9, 1930, pages 223-238, 4 figures.

Study of structure of combinations of one atom of cadmium with 3 atoms of magnesium and 1 atom of magnesium with 3 atoms of cadmium; checking of phase-rule diagrams by X-ray analysis. Report from X-ray laboratory of Stuttgart Institute of Technology.

Zinc and Cadmium for Preventing Corrosion, L. K. Wright. *Machy. (N. Y.)*, vol. 37, no. 5, Jan. 1931, page 343.

Comparison of fields of application for protecting other metals; thickness of 0.0003 in. of cadmium is considered equivalent to thickness of 0.001 in. of zinc.

Die elektrische Leitfaehigkeit und die thermische Ausdehnung der Magnesium-Cadmium Legierungen (Electrical Conductivity and Thermal Elongation of Magnesium-Cadmium Alloys), G. Grube and E. Schiedt. *Zeit. fuer Anorganische und Allgemeine Chemie*, vol. 194, no. 2-3, Dec. 9, 1930, pages 190-222, 9 figs.

Original and compiled data; phase-rule diagrams. Report from laboratories for physical chemistry and electrochemistry of Stuttgart Institute of Technology.

CASE HARDENING

Accurate Case-Hardening, H. Swain. *Metallurgia (Manchester)*, vol. 2, no. 11, Sept. 1930, pages 185-186.

Close study of process of case-hardening will lead to more accurate results; more care may involve greater cost, but there are economic compensations; efficient furnaces; carburizing compound; boxes and methods of packing; re-heating and tempering.

Thermo-Diffusion of Elements in Steel, J. H. Hruska. *Heat Treating and Forging*, vol. 16, no. 12, Dec. 1930, pages 1530-1533, 8 figs.

Carburization cyaniding and decarburization as effected by thermo-diffusion; method of carburization introduced by Hevi Duty Electric Co.; graph illustrates penetration of carbon and nitrogen into low carbon steel in cyaniding. (To be concluded.)

Carburizing with Various Gases, E. C. Cook. *Fuels and Furnaces*, vol. 8, no. 12, Dec. 1930, pages 1667-1668.

Kinds of gases that have been used for carburizing; good results obtained from using natural gas; examples of use. Abstract of paper read before Am. Soc. Steel Treating.

Thermo-Diffusion of Elements in Steel, J. H. Hruska. *Heat Treat. and Forging*, vol. 17, no. 1, Jan. 1931, pages 35-39, 4 figs.

Tables and graphs give data on analyses of steels used in nitriding; relationship between time and temperature upon depth of chromium penetration into steel; diagram showing number of crystals per sq. in. as index to normality of steels, thermo-diffusion of vanadium and silicon. (Concluded.)

Ueber die Schutzwirkung von Abdeckmitteln Gegen Zementation bei Teilweiser Oberflaechenhaertung (Protective Action of Coatings In Selective Carburizing), O. Achilles. *Werkstattstechnik*, vol. 25, no. 1, Jan. 1, 1931, pages 1-3, 7 figs.

Review of investigations on protective effect of electrolytically applied metal layers; mineral coatings and pulverized materials; methods for partial hardening of surfaces are illustrated by typical examples.

CAST IRON

Congress of Mines, Metallurgy and Applied Geology at Liége (Le Congrès des Mines, de la Métallurgia de la Géologie Appliquée, a Liége). *Fonderie Moderne (Paris)*, vol. 24, Oct. 25, 1930, pages 359-364.

Abstracts of papers presented by F. Pisek, H. Thyssen, L. F. C. Girardet, A. Deuleuse, and J. Bourdouxhe dealing with manufacture and testing of cast iron; mechanical and metallographic test methods.

Temperature Measurements on Molten Cast Iron (Temperaturmessungen an fluessigen Gusseisen), Moeller. *Dinglers Polytechnisches Jl. (Berlin)*, vol. 345, no. 11, Nov. 1930, pages 206-209, 4 figs.

Measuring range from 1250 to 1550 cent.; description of optic pyrometer "Pyropto" developed by Hartmann & Braun, for purpose.

ELECTRIC MELTING. Using Off-Peak Power for Melting Gray Iron, W. R. Jennings. *Metals and Alloys*, vol. 1, no. 17, Nov. 1930, pages 814-815, 1 fig.

Experiences of Baker-Perkins Co. of Saginaw, in operating rocking type electric furnace on cold stock melting of gray iron; charts illustrate how demand was reduced from 960 kva. to 640 kva., difference of 320 kva. which represents saving in demand charge of $5500.00 per yr.; using 590 kwh. per heat, cost of electrical energy per pound is 0.00295 cent.

(Continued on page 117)

HIGH TEST. High-Test Cast Iron. *Metallurgia (Manchester)*, vol. 3, no. 13, Nov. 1930, pages 15-16.

Rocking type of electric furnace is claimed to have opened new field for producing uniformly good high-test cast iron without use of expensive alloying elements; round table discussion on application of Detroit rocking electric furnace to production of high-duty gray iron; compare paper by R. Moldenke, previously indexed from Am. Electrochemical Soc.—Preprint, 58-27, for mtg. Sept. 25-27, 1930.

NICKEL. Study of Nickel-Vanadium and Nickel-Molybdenum Cast Iron (Etude sur les fontes au nickel-vanadium et au nickel-molybdène), J. Challansonnet. *Revue de Métallurgie (Paris)*, vol. 27, no. 11, Nov. 1930, pages 573-603, 41 figs.

First part of work deals with influence of nickel-vanadium, additions on properties of cast iron; influence of special elements on properties of synthetic cast iron; dilatometric analysis; thermoelectrical properties; influence of additions on microstructure; mechanical properties. Bibliography. (To be continued.)

Improving Gray Cast Iron with Nickel. *Technique (Montreal)*, vol. 5, nos. 7, 9, and 10, Sept. 1930, pages 26-28; Nov., pages 35-37, and Dec., pages 28-30, 4 figs.

Uses of nickel in refining grain, controlling or reducing chill, eliminating hard spots, chilled corners, improving machinability, controlling combined carbon, increasing hardness, obtaining maximum hardness, equalizing hardness in different parts of casting, increasing wear-resistance, strength and toughness. This paper is in English.

Special Quality Gray Iron Castings, W. J. Merten. *Fuels and Furnaces*, vol. 9, no. 2, Feb. 1931, pages 195-198, 12 figs.

Selective crystallization effected by various alloying elements in gray iron castings; nickel and other alloy irons and special process irons.

HEAT TREATMENT. Producing a Blue Oxidized Finish on Cast Iron, C. Weber. *Metal Cleaning and Finishing*, vol. 3, no. 1, Jan. 1931, pages 71-72.

Outline of method of oxidizing cast iron in high temperature gas furnace.

WELDING. The Use of Pure Iron Electrodes for Welding Cast Iron, H. D. Lloyd and J. S. G. Primrose. *Welding Jl.*, vol. 28, no. 328, Jan. 1931, pages 18-22, 8 figs.

Advantages of pure iron electrodes in making bed plate and repair electric motor casings; microphotographs illustrate burnt on weld in cast iron; phosphoric cast iron welded with soft pure iron.

CORROSION

Corrosion Tests of Iron and Steel in Distilled Tap and Sea Water, K. Hasegawa and S. Hori. *Ryojun College Eng.—Pub.*, no. 1, vol. 7, no. 35, 1930, 27 pages, 19 figs.

Results of tests which show corrosion losses and corrodibility of specimens of cast iron, wrought iron and five kinds of carbon steel.

Some Properties of Protective Films on Metals, E. S. Hedges. *Chem. and Industry*, vol. 50, no. 2, Jan. 9, 1931, pages 21-25.

Recent researches on some of more corrodible common metals, especially iron; effect of atmospheric oxygen on metals; protection of metals in aqueous solutions; anodic films.

Costly Rust of Metal Supply Can be Prevented if Temperature is Kept Above Dew-Point in Storage Room, J. Geschelin. *Automotive Industries*, vol. 64, no. 8, Feb. 21, 1931, pages 256-260, 5 figs.

Effect of relative humidity of air on corrosive process; chart illustrates for January to December daily relative humidity, outside temperature and dew-point temperature in Chicago during 1930.

TESTING. Corrosion Testing. *Metallurgist (Supp. to Engineer)*, Jan. 30, 1931, pages 2-3.

In England and America salt-spray test is widely used; while in Germany at all events for aluminum alloys "Mylius" test is much employed; which exposure is made to salt solution activated by addition of hydrogen peroxide; another purely chemical method has been developed; originally developed in Germany by Kroehnke and Arndt; it relies upon determination of quantity of oxygen absorbed in corrosive processes which have taken place.

DIES

Metallurgy of the Modern Die Set, J. H. Hruska. *Iron Age*, vol. 127, no. 9, Feb. 26, 1931, pages 702-705, 5 figs.

Composition and heat treatment of steels used for different parts of dies, with particular regard to die set castings, leader pins and bushings.

DIE CASTING. The Die Is the Heart of Die Casting Process. *Foundry*, vol. 59, no. 2, Jan. 15, 1931, pages 65-68, 4 figs.

Methods and equipment in manufacture of dies or molds for pressure die casting; data on permissible variation per inch of diameter or length taken from United States Army Ordnance Specifications.

FORMING AND BENDING. Dies for Bulldozing and Upsetting, G. A. Smart. *Heat Treat. and Forging*, vol. 17, no. 1, Jan. 1931, pages 46-49, 7 figs.

Sketches illustrate principles of upsetter die design; selection of steel; cooling dies and punches.

ELECTRIC FURNACES

ANNEALING. Recent Developments in the Design of Electric Annealing Furnaces for Metals, W. Meckenhauser. *Metal Industry (Lond.)*, vol. 38, no. 6, Feb. 6, 1931, pages 159-162, 7 figs.

Progress and invention in sphere of electric annealing; possibility of high average load factor; full automatic control; continuous strip annealing furnaces.

INDUCTION. The Coreless Induction Furnace in a New Role, A. G. Robiette. *Iron and Steel Industry*, vol. 4, no. 4, Jan. 1931, pages 125-129, 4 figs.

Review of possibilities of this furnace as refining appliance; data on furnace linings; carbon removal; dephosphorization; oxidizing with ore while melting; economies of induction steelmaking.

Die elktrodynamischen Badbewegungen bei Induktionsoefen (Electrodynamic Bath Movements in Induction Furnaces), E. F. Russ. *Archiv fuer das Eisenhuettenwesen*, vol. 4, no. 6, Dec. 1930, pages 277-280, 5 figs.

Pinch effect in open induction furnaces, first advanced by Hering in 1907 and later developed by Northrup; eddy-force effect in all induction furnaces and bath movement caused thereby; eddy-force effect in liquid and solid conductors.

ELECTRIC WELDING

A New System for Direct Current Arc Welding, S. R. Bergman. *Am. Inst. Elec. Engrs.—Advance Paper*, no. 19, for mtg. Jan. 26-30, 1931, 3 pages, 4 figs.

Short description of d. c. generator having characteristics suitable for arc welding; curves showing performance under steady conditions of load are shown; for quick changes of load transients appear detrimental to arc welding; to eliminate these transforming reactor is introduced in arc welding circuit; transforming reactor which has dual purpose; depresses transients and introduces reactance in arc circuit which, experience has shown, is desirable in order to make arc stable and therefore easy to handle.

An Improved Arc Welding Generator, J. H. Blankenbuehler. *Am. Inst. Elec. Engrs.—Advance Paper*, no. 13, for mtg. Jan. 26-30, 1931, 5 pages, 8 figs.

Welding operator may encounter trouble in starting arc or in having arc extinguish itself too readily; those causes of trouble which are attributed to welding generator are analyzed and explained in terms of generator design; means for eliminating generator characteristics causing these troubles, is outlined and results obtained are shown by oscillographic records.

Resistance Butt Welding of Tools. *Welding Engr.*, vol. 16, no. 1, Jan. 1931, pages 41-42, 5 figs.

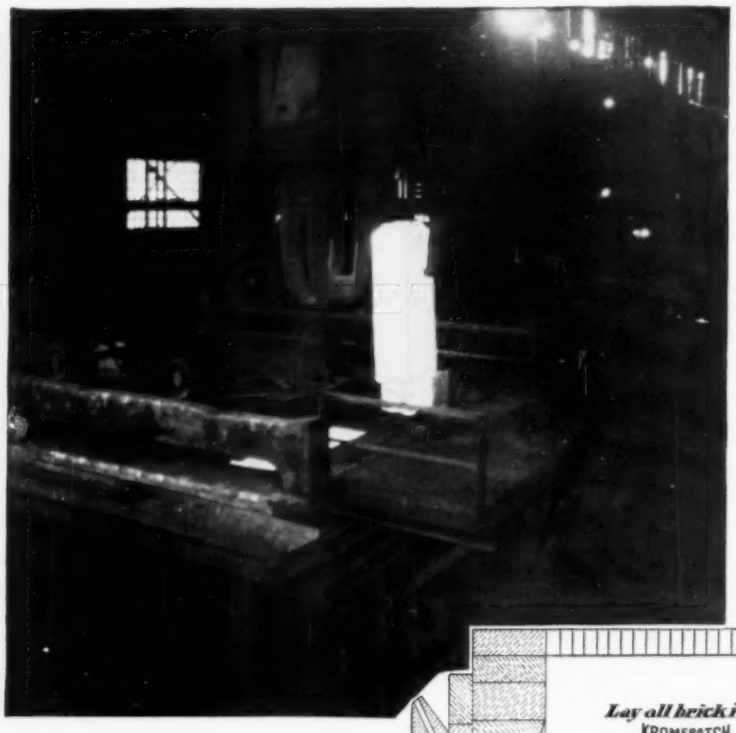
Design and performance of machines suited particularly for welding of drills and other precision tools.

FORGINGS

A New Forging Defect, Its Cause and Cure, W. E. Jominy and A. M. Steever. *Metal Progress*, vol. 19, no. 1, Jan. 1931, pages 94-97, 6 figs.

Investigation of defect due to localized carburization occurring during heating bar stock or billets in forging furnace; microphotograph illustrates crystal structure of various steels.

(Continued on page 126)



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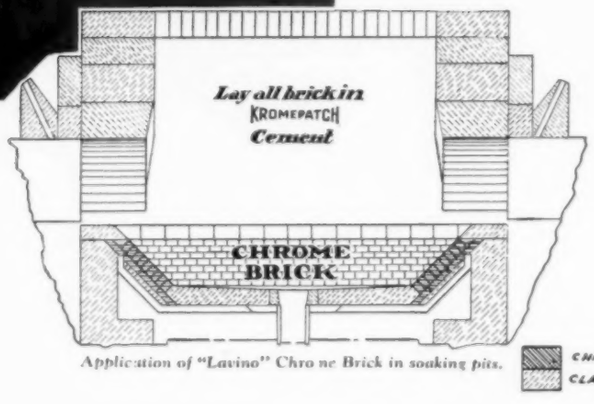

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Up That Pencil

Heating for Forging, R. M. Keeney. *Metals and Alloys*, vol. 2, no. 1, Jan. 1931, pages 3-7.

Fundamentals of forging practice and effect of different forging methods on physical properties; data on forging temperatures of various steels and effect of rate of heating on heat penetrations at 2200 deg. fahr. for different sizes and shapes; design and requirements of forging furnaces.

GAS FURNACES

Industrie-Gasoefen auf dem Stand der Berliner Staedtische Gaswerke A.-G., Deutsche Ausstellung Gas und Wasser Berlin 1929 (Industrial Gas Furnace Exhibited by Berliner Staedtische Gaswerke A.-G., German Gas and Water Exhibition of Berlin 1929), G. Steffany. *Gas und Wasserfach*, vol. 73, no. 51, Dec. 20, 1930, pages 1217-1219, 6 figs.

Features of several types of gas-fired furnaces for riveting, steel treating, forging, etc.

Carburizing with Gas in Underground Retorts, W. F. McNally. *Metal Progress*, vol. 19, no. 1, Jan. 1931, pages 39-43, 14 figs.

Design and operation of various types of gas carburizing machines and accessories; data on composition of city gas of 530 b. t. u. used for carburizing; microphotograph illustrates case, transition and core of piece carburized with natural gas, and solid material.

HARDNESS TESTING

Die Haertepruefung mit Tiefenmessung (Hardness Testing with Depth Measurements), O. Dettinger. *Maschinenbau*, vol. 10, no. 1, Jan. 1931, pages 14-18, 8 figs.

New machine for depth measurement method utilizing ball of 2.5 mm. diam. and load of 187.5 kg.; investigation of accuracy of depth measurement methods with regard to determination of Brinell hardness; possibility of finding tensile strength by means of depth measurement method.

A New Hardness Testing Machine. *Ry. Engr.*, vol. 52, no. 612, Jan. 1931, page 33.

Direct reading machine, rapid in operation and well adapted for testing mass production work; design and operating features.

HEAT TREATMENT

Some Unusual Metallurgical Applications and Uses of Fused Baths, W. J. Merten. *Fuels and Furnaces*, vol. 9, no. 1, Jan. 1931, pages 51-52.

Decomposition of nitrides in cyanided parts and in arc-welded parts, blueing steel surfaces to prevent corrosion, and obtaining maximum use of metal by means of fused salt baths and high-temperature salt baths.

Heat Treatment of High-Duty Bearing Balls, R. E. Coward. *Iron and Steel*, vol. 14, no. 1, Jan. 1931, pages 3-4 and 17-19, 3 figs.

General procedure of heat treatment; hardening, quenching and tempering; rotary furnaces have many advantages; stationary furnaces used for large balls; cupola process. From Black and White.

HIGH-SPEED STEEL

Ueber den Einfluss von Nickel und Mangan auf die Eigenschaften von Schnelldrehstahl (Effect of Nickel and Manganese on Properties of High-Speed Steel), V. Ehmcke. *Kruppsche Monatshefte*, vol. 11, Dec. 1930, pages 295-315, 35 figs.

Investigation of steel of normal composition, but containing nickel addition of from 2 to 50 per cent; microphotographs and curves illustrate results of hardening and tempering tests with regard to influence of increased quantity of austenite structure.

LUBRICANTS

Utilization of Proper Fluids Will Pave the Way to Economies in Production, J. Geschelin. *Automotive Industries*, vol. 64, no. 7, Feb. 14, 1931, pages 228-232, 5 figs.

Study of functions of cutting fluids with particular regard to factors such as tool form, finish and mechanics of cutting process; procedure for testing machine tool cutting fluid.

MALLEABLE IRON

Cupola Malleable Cast Iron, H. H. Shepherd. *Foundry Trade Jl.*, vol. 44, nos. 754, 755 and 756, Jan. 29, 1931, pages 83-84, Feb. 5, pages 102-104 and 109 and Feb. 12, pages 125-128 and (discussion) 128-129, 16 figs.

Jan. 29: Cupola malleable cast iron, as referred to by author, is process by which metal is melted in cupola only and annealed to give American black-heart fracture malleable; writer's object is to prove that good type black-heart malleable can be made by cupola; patterns; core equipment; molding equipment. Feb. 5: box equipment; molding sands. Feb. 12: Melting practice; annealing; inspection and sorting.

Ueber hochwertigen Temperguss (High-Test Malleable Cast Iron), E. Piwowarsky. *Giesserei*, vol. 18, no. 1, Jan. 2, 1931, pages 19-24, 14 figs.

Advantages of malleable over steel and gray-iron castings; white-heart malleable; influence of wall thickness and manganese content; metallurgical advantages of black-heart malleable; possibilities of treatment; influence of chemical composition, initial temperature, cooling conditions and special elements, especially nickel and chromium; price of malleable castings.

Der Temperguss (Malleable Iron Castings), P. Vidor. *Giesserei*, vol. 18, no. 1, Jan. 2, 1931, pages 8-14, 6 figs.

Applications of malleable castings; composition; main constituents of iron; importance of carbon, silicon, manganese, phosphorus, sulphur and their reciprocal effects; transformation phenomenon in annealing furnace; preparatory treatment, pattern making, molding, melting, and casting; importance of sand and core.

METALLOGRAPHY

The Macroexamination of Steel, M. G. Yatsevitch. *Army Ordnance*, vol. 11, no. 64, Jan.-Feb. 1931, pages 297-305, 10 figs.

Sur la Perlite sa structure et ses propriétés mécaniques (Structure and Mechanical Properties of Pearlite), N. T. Belaiew. *Revue de Métallurgie*, vol. 27, no. 12, Dec. 1930, pages 680-685, 7 figs.

Results of micrographic investigation on relation between physical properties and crystal structure with particular regard to distance between cementite lamellae.

Die Konstitution und Bildung des Phosphideutektikums im Gusseisen (Constitution and Formation of Phosphide Eutectoid in Cast Iron), M. Kuenkele. *Giesserei*, vol. 18, nos. 4 and 5, Jan. 23, 1931, pages 73-78, and Jan. 30, pages 94-98, 37 figs. partly on supp. plates.

New etching process and its application to analysis of constitution of phosphide eutectoid of series of cast-iron specimens; results show that in gray cast-iron, ternary cementite-bearing phosphide eutectoid, as well as binary eutectoid containing only iron phosphide and mixed crystals, occur; quenching and thermal tests showed that binary eutectoid was actually a ternary (pseudo-binary) eutectoid.

METALLURGY OF STEEL

Ueber den Sproedigkeitsbereich von Eisen bei tiefen Temperaturen (Range of Brittleness of Iron at Low Temperatures), F. Sauerwald, B. Schmidt and G. Kraemer. *Zeit. fuer Physik*, vol. 67, no. 3-4, Jan. 21, 1931, pages 179-183, 5 figs.

Experimental study of brittleness of monocrystalline and polycrystalline irons, including mild steel, at temperatures of minus 90 to minus 185 deg. cent., made at Breslau Institute of Technology.

Ueber die Abkuehlung von Koerpern mit inneren Waermequellen (Cooling of Bodies with Internal Heat Sources), H. Schmidt and W. Uhink. *Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung*, vol. 12, no. 20, 1930, pages 323-342, 25 figs. 3.-r.m.

Numerical calculation of temperature field in interior of infinitely long iron cylinders and of iron spheres with cooling of which heat sources arise internally; temperature distribution in relation to time; time-temperature curves are developed.

BIBLIOGRAPHY. Review of Iron and Steel Literature for 1930. E. H. McClelland. *Blast Furnace and Steel Plant*, vol. 19, no. 2, Feb. 1931, pages 258-261.

Classified list of more important books, serials and trade publications published during the year.

NITRIDING

Nitriding of Alloyed Steels, W. J. Merten. *Heat Treat. and Forging*, vol. 17, no. 1, Jan. 1931, pages 27-30, 6 figs.

Principles of nitriding and effect on physical properties; design and operation of bell type furnace, .75 kw., 220 v., 3 phase; selective nitriding.

(Continued on page 130)

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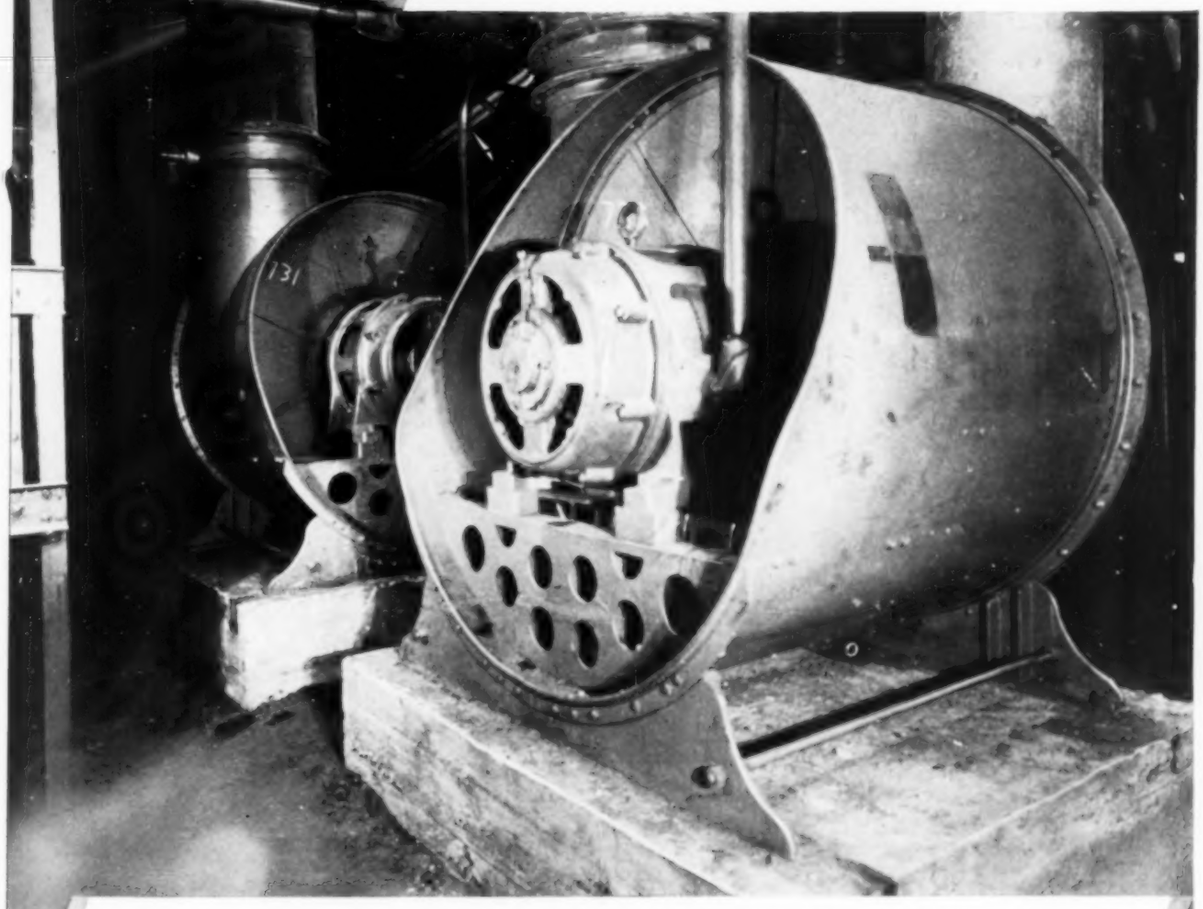

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Ueber die Nitrierung von Eisen und Eisenlegierungen (Nitridation of Iron and Iron Alloys), W. Eilender and O. Meyer. *Archiv fuer das Eisenhuettenwesen*, vol. 4, no. 7, Jan. 1931, pages 343-352, 21 figs.

Nitridation of pure iron; diffusion of nitrogen in pure iron and in iron-carbon alloys; change in structure and hardness of nitrided iron alloys; mechanism of nitride hardening.

NON-FERROUS CASTINGS

Problems in the Brass Foundry, W. J. Reardon. *Metal Industry (N. Y.)*, vol. 29, no. 1, Jan. 1931, page 23, 1 fig.

Answers to questions on following: flux for aluminum-iron alloy; die casting metal; bronze pressure casting.

Large Non-Ferrous Castings, W. Lambert. *Metal Industry (Lond.)*, vol. 38, no. 4, Jan. 23, 1931, pages 111-112.

Properties and composition of manganese bronze; application to marine engineering. Before Manchester Met. Soc.

OPEN HEARTH

Die waermetechnische Messanlage an den Siemens-Martin-Oefen der Rasselsteiner Eisenwerke (Heat Measuring Equipment at Siemens-Martin Furnace of Rasselstein's Steel Plant), K. H. Moll. *Siemens-Zeit.*, vol. 10, no. 12, Dec. 1930, pages 615-620, 8 figs.

Furnace has been equipped during past two years with measuring installation with which continuous control over melting operations is effected; details of installation by Siemens and Schuckert.

Rapid Open-Hearth Furnaces, N. E. Skaredoff. *Iron and Coal Trades Rev.*, vol. 122, no. 3281, Jan. 16, 1931, page 81.

Furnaces designed by author and built at Kamaishi Steel Works in Japan; instead of usual two or three charges daily, it is possible to get five or six charges from each daily; furnace capacity 25 tons; charge is 20 to 30 per cent molten from blast furnace direct, 20 to 30 per cent cold pig, 35 to 50 per cent steel scrap; fuel is coke oven gas and coal tar; fuel consumption less than half of that for ordinary furnaces, per ton of product.

The Open-Hearth Steel Process as a Problem in Chemical Kinetics, E. R. Jette. *Am. Inst. Min. and Met. Engrs.—Tech. Pub.*, no. 380, for mtg. Feb. 1931, 34 pages, 2 figs.

Mathematical development of equations which represent rate of change of ferrous oxide content of metal with time; review of literature on chemical reactions in open-hearth steel bath; analysis of complex set of reactions and processes comprised in open hearth steel process. Bibliography.

OXYACETYLENE CUTTING

Untersuchungen ueber wirtschaftliches Brennschneiden (Investigation of Economy of Oxyacetylene Cutting), C. Assmann. *Autogene Metallbearbeitung*, vol. 24, no. 1, Jan. 1, 1931, pages 4-14.

Review of previous research work and investigation of pressure loss between reduction valves and cutting tip; test setup and results of experiments for determining specific oxygen consumption as function of cutting speed and of muzzle velocity of cutting jet in different size tips.

Untersuchungen ueber wirtschaftliches Brennschneiden (Investigation of Economy of Oxyacetylene Cutting), C. Assmann. *Autogene Metallbearbeitung*, vol. 24, no. 2, Jan. 15, 1931, pages 26-32, 6 figs.

Detailed analysis of factors affecting cost, and graphical representation of cost per m. as function of diameter of cutting jet, gas pressure and cutting velocity.

Autogen-Kurvenschneidmaschinen (Autogenous Curve-Cutting Machines). *Zeit. fuer Schweisstechnik (Journal de la Soudure)*, vol. 20, no. 12, Dec. 1930, pages 365-370, 12 figs.

Design and application of curve cutting machines with particular regard to models KW, KS, and FM 54.

OXYACETYLENE WELDING

The Importance of Procedure Control in Welding, C. D. Jax. *Louisiana Eng. Soc.—Proc.*, vol. 16, no. 5, Oct. 1930, pages 19-206.

(Continued on page 132)

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"TRUE economy lies in developing proper technique, rather than in rejecting poor work." You will agree with this statement of a prominent physicist. Find out whether castings have blow holes, shrinking cavities, cracks, or what. Then the defects can usually be eliminated.

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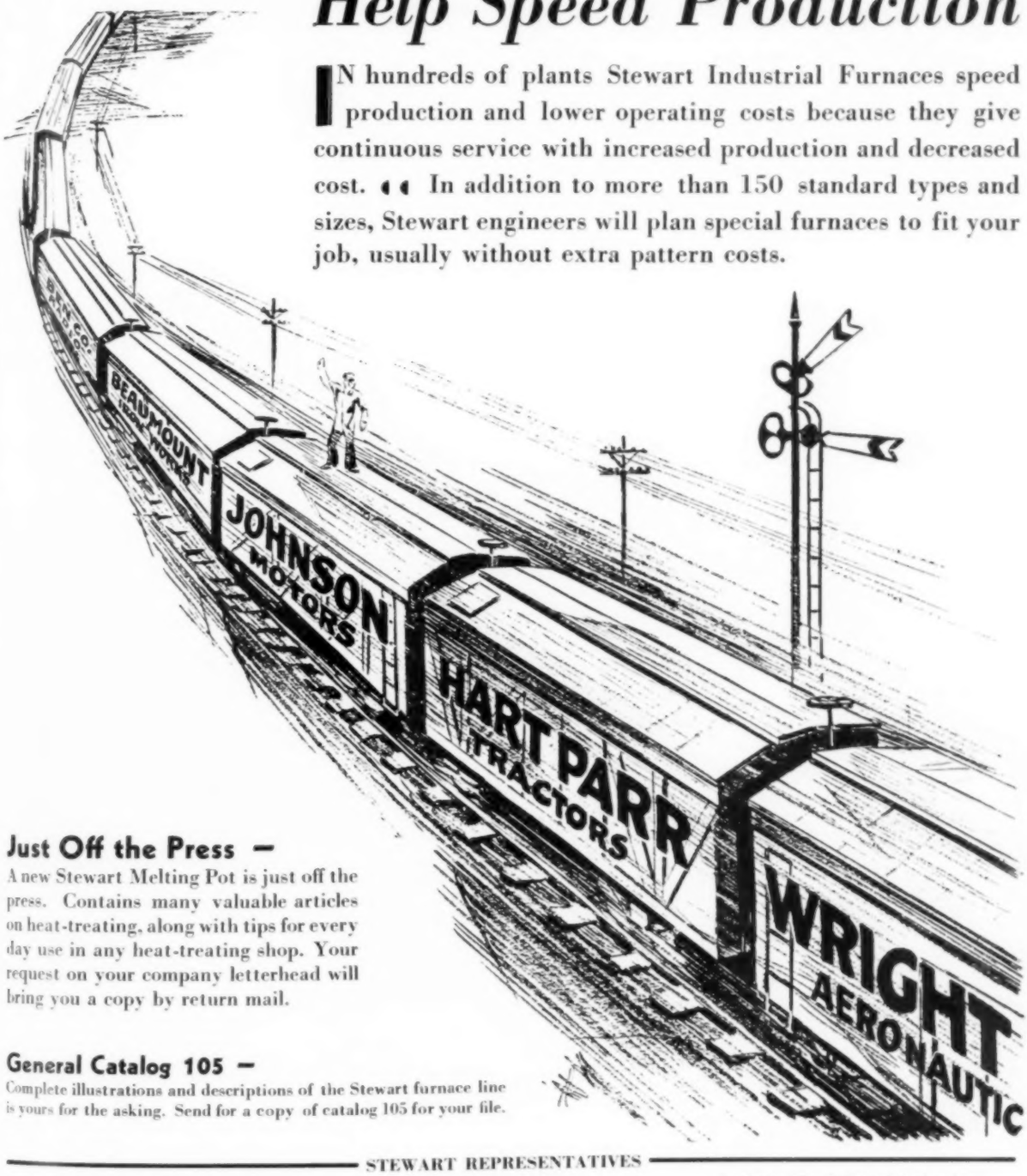

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Six factors of procedure control are: check of welders; selection and inspection of material; design and layout of welded joints; preparation for welding; organization and welding technique; inspection and test.

Welche Faktoren beeinflussen die Guete der Schweissnaht beim Gasschmelzschweissen (What factors Control Quality of Seam in Gas Fusion Welding), E. Kalisch. *Autogene Metallbearbeitung*, vol. 23, no. 24, Dec. 15, 1930, pages 384-387, 6 figs.

Effect of materials to be welded and composition of welding rods; microphotographs illustrate effect of temperature and welding speed.

Schweissen von Rohrleitungen (Welding of Pipe Lines), C. F. Keel and O. Roethlin. *Zeit. fuer Schweisstechnik (Journal de la Soudure)*, vol. 20, no. 11, Nov. 1930, pages 341-343.

Practical suggestions for application of oxyacetylene welding in fitting of pipes in domestic installation, with particular regard to joining pipes of different diameter.

PICKLING

The Pickling and Cleaning of Metals, D. Brownlie. *Sheet Metal Industries*, vol. 4, no. 9, Jan. 1931, pages 768-770.

Use of nitre cake, alkalis and alkaline salts; methods used for removing oil and grease. (Continuation of serial.)

The Pickling and Cleaning of Metals—VI, D. Brownlie. *Sheet Metal Industries*, vol. 4, no. 10, Feb. 1931, pages 862 and 864.

Construction and operation of tanks; methods used for agitating contents of pickling baths.

REFRACTORIES

Pastas Extra Refractarias Para el Uso en Laboratorios (Super-Refractory Compounds for Laboratory Use), M. Feliu. *Quimica Industria*, vol. 7, no. 82, Nov. 1930, page 280, 1 fig.

Porcelain and fireclay ware usually employed permit laboratory work with temperatures up to 1300 deg. cent.; super-refractories melt or soften near 1800 deg. cent. or higher; advantages of Pythagoras compound supplied by porcelain manufacturer of Berlin.

Einfluss der Schamottekorngroesse und -Menge, sowie der Brenntemperature auf die physikalischen Eigenschaften von feuerfesten Baustoffen (Influence of Grain Size and Volume of Fireclays on Physical Properties of Refractory Materials), F. Illgen. *Berichte der Deutschen Keramischen Gesellschaft*, vol. 11, no. 12, Dec. 1930, pages 649-674, 13 figs.

Special regard is given to tensile strength at high temperatures and new method is developed for determining rupture resistance and tensile softening point of refractory clays, which are subjected directly or indirectly to tensile stress.

SLAG

Research on Blast-furnace Slags, R. S. McCaffery. *Am. Inst. Min. and Met. Engrs.—Tech. Pub.*, no. 383 for mtg. Feb. 1931, pages 5-26, 79 figs.

Progress report on research on high blast furnace slags, in progress since 1922 in metallurgical department of University of Wisconsin, supplemented by observations, tests and critical examination of operating records at 10 furnaces; information from data collected is presented in form suitable for use by blast-furnace operators. Bibliography.

Effect of Magnesia on Slag Viscosity, R. S. McCaffery, J. F. Oesterle and O. O. Fritsche. *Am. Inst. Min. and Met. Engrs.—Tech. Pub.*, no. 383 for mtg. Feb. 1931, pages 55-68, 30 figs.

Method of obtaining data is explained in pages 27-54; report on results, continuing work reported in earlier papers; data are in form of temperature-viscocity curve for any slag of particular composition; from these curves, viscocity of slag of definite composition and at definite temperature is taken off and is plotted on plane triaxial diagram showing compositions of silica lime and alumina on plane representing constant-magnesia content. Bibliography.

STEEL CASTINGS

Ein Beitrag zur Warmrissbildung an Stahlgusstuecken (High-Temperature Crack Formation of Steel Castings), K. Singer and H. Bennek. *Stahl und Eisen*, vol. 51, no. 3, Jan. 15, 1931, pages 61-65, 10 figs.

Investigation of origin and possibilities of refilling cracks, based on practical examples; segregation of shrinkage as cause of cracks; time of crack formation; influence of cross-section and cooling conditions.

Sparsame Wirtschaft im Giessereibetrieb (Economy in Foundry Practice), Freytag. *Giesserei*, vol. 18, no. 5, Jan. 30, 1931, pages 93-94, 5 figs.

Patterns for group of steel castings for inductors were replaced by templets and core boxes, and it is claimed castings thus obtained are superior to those made with patterns, when molder and coremaker are conscientious in their work.

STEEL MANUFACTURE

Untersuchungen ueber die chemischen Vorgaenge bei den sauren Stahlerzeugungsverfahren, etc., (Studies of Chemical Phenomena in Acid Steel Manufacturing Process), H. Schenk. *Archiv fuer das Eisenhuettenwesen*, vol. 4, no. 7, Jan. 1931, pages 319-332, 10 figs.

Metallurgical similarity of reactions of manganese and silicon with acid process and with deoxidation can be utilized to draw conclusions for one process from the other; after determining dissociation constants of silicates, conditions for equilibrium between metal and slag and deoxidation product are shown diagrammatically.

Steel Ingots, W. H. Hatfield. *Metallurgist (Supp. to Engineer)*, Jan. 30, 1931, pages 8-12, 4 figs.

Account of work done by "Heterogeneity Committee", both as regards exploration of characteristics of steel ingots and also as regards study of mechanism of freezing, with view to bringing about technical improvement; Committee, one of those appointed by Iron and Steel Institute in 1924, has already published three reports in Journal of Iron and Steel Institute in 1926, 1928 and 1929, respectively.

Characteristics of Rimmed Steel, E. C. Bitzer. *Blast Furnace and Steel Plant*, vol. 19, no. 2, Feb. 1931, pages 249-251, 2 figs.

Definition of quality of rimmed steel with particular regard to effects of chemical reactions within ingot; origin of gases and use of aluminum.

The Influence of Atmosphere on the Scaling of Mild Steel, W. H. Blackburn and J. W. Cobb. *Chem. and Industry (Lond.)*, vol. 49, nos. 48 and 49, Nov. 28, 1930, pages 455T-462T, and Dec. 5, pages 463T-466T, including discussion, 7 figs.

Object of investigation was to get some idea, by laboratory experiments, of what steps could be taken to reduce amount of scaling of mild steel, having regard to fuel economy and also to possibility of reducing or eliminating smoke nuisance consequent on use of smoke flame; calculation of heat expenditure involved in prevention of sealing by addition of reducing gas.

Temperature-Viscosity Relations in the Lime-Silica System, C. H. Herty, Jr., F. A. Hartgen, J. A. Heidish, K. Metcalfe, F. G. Norris and M. B. Royer. *Min. and Met. Investigations—Bul.*, no. 47, 1930, 27 pages, 13 figs.

Investigation to determine relations between viscosity, temperature, and composition for portion of lime-silica system fusible at steel-making temperatures; apparatus embodies principles of Margules; it is believed that high viscosity in basic open-hearth slags is caused by formation of complex silicates without marked dissociation at temperature obtained. Bibliography.

Tonnage Melting by Coreless Induction, E. F. Northrup. *Iron Age*, vol. 127, no. 3, Jan. 15, 1931, pages 228-233, 7 figs.

Operating principles and application of high-frequency induction furnaces including data on power requirements, size of furnaces and refractory materials.

Gas Flow in Open-Hearth Furnaces. *Foundry Trade Jl. (Lond.)*, vol. 43, no. 745, Nov. 27, 1930, page 378.

Method of increasing output from open hearth furnaces by increasing amount of gas burned.

STEEL TESTING

Zur Bestimmung der Dauerstandfestigkeit im Abkuerzungsverfahren (Determination of Endurance by Abbreviated Testing Method), A. Pomp and W. Enders. *Stahl und Eisen*, vol. 51, no. 6, Feb. 5, 1931, pages 157-162, 11 figures.

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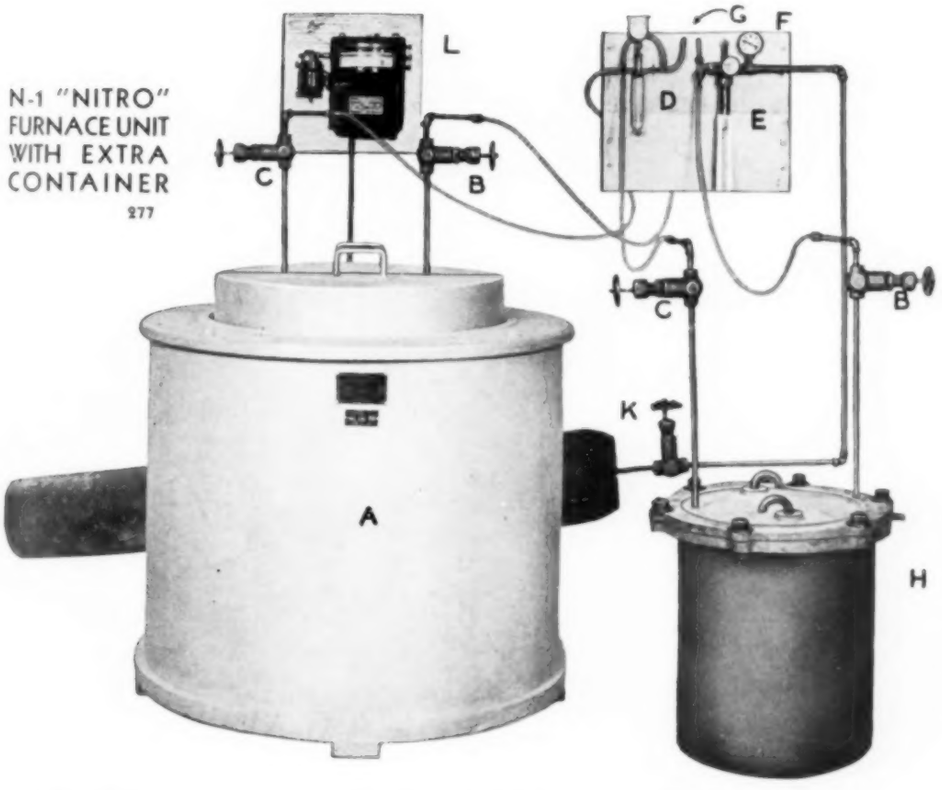

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Resistance Thermometers — Leeds and Northrup Co. Revised catalog treating in detail resistance thermometers for recording, controlling and indicating temperatures, covering heating and ventilating, applications in refrigeration and chemical plants, gas-making and other low temperature applications. Bulletin F-19.

Steel Handbook—Jos. T. Ryerson & Sons, Inc. Handbook on Tool and Alloy Steels. Description, technical data and general information on tool and alloy steels. Also non-technical description of heat treating methods and shop practice applying to various steels. Bulletin F-18.

Induction Furnaces—Ajax Electrothermic Corp. This bulletin gives latest information regarding coreless induction furnaces in capacities up to several tons, and motor-generator equipments for energizing the furnaces. Bulletin F-17.

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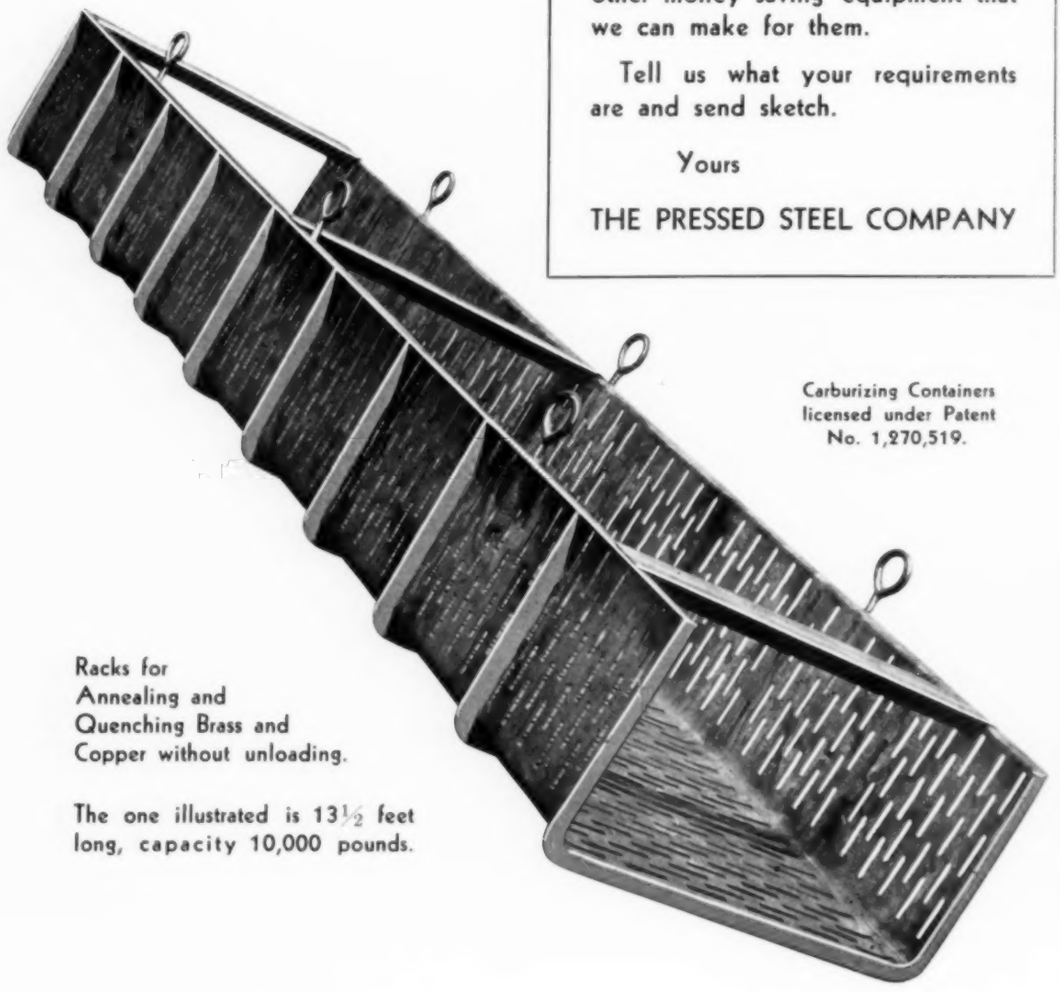

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